A

TREATISE

Containing the

ELEMENTARY PART

OF

FORTIFICATION,

REGULAR AND IRREGULAR.

WITH

REMARKS on the Constructions of the most celebrated Authors, particularly of Marshal de VAUBAN and Baron COEHORN, in which the Perfection and Imperfection of their several Works are considered.

For the USE of the

Royal Academy of ARTILLERY at Woolwich.

Illustrated with Thirty-Four Copper Plates.

The THIRD EDITION.

By JOHN MULLER,
Professor of ARTILLERY and FORTIFICATION.

LONDON,
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To his GRACE

J O H N

Duke of MONTAGU, &c.

One of his Majesty's most honourable Privy-council, Great Master of the most honourable Order of the Bath, *Knight of the most noble Order of the Garter, Master of the King's great Wardrobe, Colonel of the Queen's royal Regiment of Horse, and Master-general of the Ordnance,* &c.

May it please your Grace,

THE institution of the royal academy for the instruction of military gentlemen, will be a lasting monument of your Grace's attention to his Majesty's service, and of your encouragement of useful learning.

As your Grace has been pleased to appoint me to instruct the young gentlemen of the academy, and this work having been compiled for their improvement, it naturally claims your Grace's patronage; which, if I am so happy to obtain, will gratify the utmost of my wishes, as I have thereby an opportunity of assuring your Grace of the sense I have of your goodness and generosity, and of the gratitude with which I am most respectfully,

Your Grace's

most obedient

and most devoted

humble servant,

From the Royal Academy at
Woolwich, August 27th, 1746.

John Muller.

THE

PREFACE.

SINCE the invention of gunpowder, fortification has received various improvements, and many have been the books wrote upon this ſubject, which might incline one to think, that it was arrived to its utmoſt perfection; but upon an impartial ſurvey of moſt of the writers, it will be found, if I miſtake not, that many of them are deficient either in theory or practice, and others blinded by prejudice, ſo that there is much room left to exerciſe the genius and excite the induſtry of thoſe whoſe buſineſs leads them to this ſtudy; beſides, as the art of attacking received ſeveral improvements in the late wars, it ſhould follow that the art of fortifying requires likewiſe improvements in proportion.

Not a few authors have proceeded upon maxims, ſome of which are uncertain, others trifling, and they have often neglected thoſe which are ſelf-evident; this together with their adopting ſome favourite ſcheme has retarded its progreſs.

Particular care ſhould be taken, in tracing plans on paper, in order to know whether

they are practicable or not; which has been neglected by many, even by some of those who are generally esteemed the best writers.

Some think it sufficient, that they make schemes with a great many outworks upon outworks, so as these works defend each other; without considering whether the town thus surrounded is spacious enough to hold, besides the inhabitants, a garrison sufficient to defend it: or the expence it would require to maintain them, and likewise the necessary stores: it is true they never fail to tell you that they have some secret, which enables them to build for half the cost that others do.

Notwithstanding the art of fortifying irregular places is most useful, yet no author, whom I know, has given the least hint or direction whereby to judge of the advantage or disadvantage of the several parts of such a place: all they have done consists in giving some schemes of their own fancy, and telling us no work ought to be made without being defended by some other; not considering that although the parts defend each other, there may be some which are much stronger than others.

For the true art consists in making an irregular fortification every where equally strong, which

which they seemed to be ignorant of, or if they knew it, they could not distinguish the strong from the weak.

The commentators on M. *Vauban*'s methods, who are so lavish in his praises, do not mention any thing of his way of fortifying irregular places; although he understood it better than any one, as appears by a great many examples of this kind; neither has any of them shewn why he made always the exterior side next to a river much longer than any other, as may be seen in the plans of *Hunningen*, and *Sarrelouis*; yet it is unquestionable that a man of so much experience had some very good reasons for what he did.

The very same mistake is made with regard to M. *Coehorn*, by those who praise him to the skies, on account of his treatise which he published before he had acquired so that great experience, for which he was justly esteemed in his latter years; and it is an undoubted proof that he himself was of the same opinion afterwards, since he did not use any of the methods published in his book when he fortified *Bergen-op-Zooom* and part of *Manheim*: had he left us in writing that knowledge which he acquired by his great experience, it would have undoubtedly been

worthy of ſo great a man, and would have perfectly juſtified the high opinion the world conceived of him.

It will not be improper to mention *Daniel Specke*, who publiſhed a book of fortification in the year 1589 at *Straſbourg* in the *German* language, which M. *Coehorn* has chiefly followed, as may be ſeen by comparing their works; and *Dilichius*, who publiſhed his *Peribologia* in the year 1640, at *Frankfurt* on the *Main*, in *German* and *Latin* was followed by M. *Vauban*; ſince there is nothing in this author, beſides his concave flanks, but what is to be found in the other.

Theſe two *German* authors were undoubtedly the beſt in their times, and as it were the fountains from which the preſent methods are derived: the few improvements made ſince are ſufficient proofs of their ſkill, and at the ſame time of the barrenneſs of invention of thoſe ſince.

As M. *Vauban*'s methods are now moſt in vogue, and chiefly uſed all over *Europe*; we thought it would not be improper to explain them firſt, and after his, thoſe of M. *Coehorn*, which are next in eſteem; and then lay down ſome principles, whereby the advantage or diſadvantage of a fortification may

be known; after this, we have examined their methods in each part ſeparately, and pointed out their ſeveral deficiencies, and afterwards have given ſome of the ſame works with proper corrections.

Then we propoſe three different methods which we hope are not altogether to be deſpiſed, and which we think might be uſed according to the different ſituations and importance of places: this with the conſtructions of ſome of the moſt celebrated authors and their examination, finiſhes the regular part of fortification.

We begin the irregular, by ſhewing how a place, that cannot be made regular, may be made ſo, as one half may be ſimilar and equal to the other half; then we enquire which part of ſuch a fortification is ſtrongeſt and which is weakeſt; theſe principles, which are demonſtrable, ſerve to judge of the weakeſt and ſtrongeſt part of any irregular fortification whatſoever; and for a farther confirmation of the truth of them, we refer the reader to ſeveral places in *Flanders* fortified by the greateſt maſters, and which agree exactly with what we have advanced.

As the greateſt ſtrength of this, and all maritime nations, conſiſts in traffic, and as fortified

fied places which lie near rivers, lakes, creeks, or the ſea, chiefly ſerve to protect and promote trade, we have dwelled upon and explained their conſtructions in a more particular manner, and nothing has been omitted that could be thought of, which might any ways contribute to the right underſtanding this ſubject.

Several examples are given, in order to ſhew, how and in what manner the reader may proceed, if he finds himſelf employed in the conſtruction of ſuch places; the ſeveral advantages and diſadvantages of their ſituations are carefully examined, and thoſe which require leaſt expence to fortify, and are moſt convenient in other reſpects, are diſtinguiſhed; for a further explanation we have examined ſeveral ſea-port towns, and pointed out thoſe which deſerve to be imitated, and others, which ſhould be avoided; the plan of *Toulon* with its harbour is inſerted, as being one of the beſt in *Europe*: laſtly, we have given the principal conditions required in the conſtruction of ſuch places. Having thus far explained the ſeveral parts of irregular fortification, we proceed to ſhew how citadels are to be joined to places, and the faults committed in ſome of the fineſt in *Europe* are pointed out; the work concludes with the

the manner of building forts, where particular notice has been taken of the methods generally followed in the building of ſuch works, near rivers and the ſea, and ſhewn their ill conſequences : as this ſubject is very important to this nation, on account of the many forts we have and daily build, ſo we have endeavoured to point out themoſt proper manner, in which they ſhould be made.

The preſent undertaking contains the theoretical part of fortification only, that which relates to the practice has been treated in another volume, ſo that the whole together makes a complete treatiſe of fortification, containing all the moſt material principles neceſſary to an *Engliſh* engineer. I may venture to ſay, that whoever reads it with proper attention, will find no endeavours have been wanting to explain every thing that is neceſſary in as ſhort a compaſs as was poſſible.

In this edition, particular care has been taken to enlarge the explanations of the conſtructions and remarks wherever it was thought neceſſary, in order to ſet every thing in as clear a light as we could : for nothing elſe ſeemed to be wanting to complete the work.

THE

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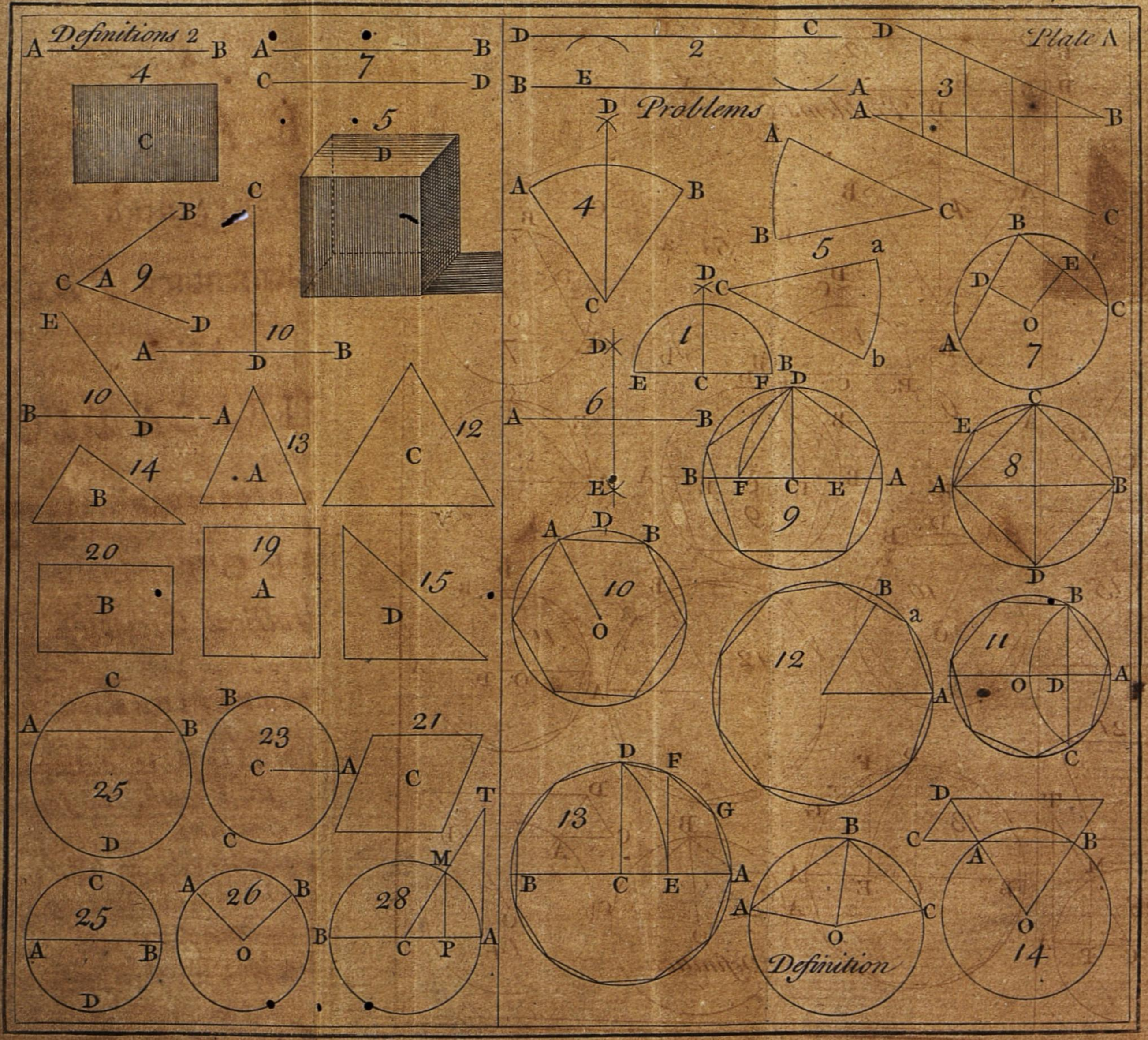
Definitions
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Definition

A

TREATISE

CONTAINING

The Elementary PART

OF

FORTIFICATION.

SECT. I.

Of practical Geometry.

DEFINITIONS.

1. EXTENSION is distinguished into *length*, *breadth*, and *thickness*, which are called *dimensions*. Plate A.

2. A *line* has only length, as AB.

3. The terms or bounds of a line are called *points*, and have no dimensions.

4. A *surface* has length and breadth only, as C.

The bounds of a surface are lines.

5. A *ſolid* has length, breadth, and thickneſs, as D.

The bounds of a ſolid are ſurfaces.

6. A *right-line* is the ſhorteſt that can be drawn from one point to another.

7. *Parallel lines* are thoſe which are every where equidiſtant, although produced *ad infinitum*, as AB, CD.

8. A *plane ſurface* is that which lies evenly between its bounds, and agrees with a right line placed on it according to any poſition.

9. The opening of two lines, which meet each other in a point, is called an *angle*, as A.

N. B. An angle is generally expreſſed by three letters, as ABC, with the letter expreſſing the angular point in the middle.

10. If a line CD meets another line AB, ſo that the angles CDA, CDB, are equal; that line CD, is ſaid to be *perpendicular* to the other AB.

And the equal angles CDA, CDB, are called *right angles*.

But if the line is oblique, as DE, the greateſt angle EDA, is called an *obtuſe* angle; and the leaſt EDB, an *acute* angle.

11. A

11. A plane ſurface terminated by three right lines, is called a *plane triangle*.

12. When the three ſides of a triangle are equal, it is called an *equilateral triangle*, as C.

13. When only two ſides are equal, an *iſoſceles triangle*, as A.

14. When the three ſides are unequal, a *ſcalene triangle*, as B.

15. When one angle of a triangle is a right angle, it is called a *right-angled* triangle, as D.

16. Any one ſide of a triangle may be called the *baſe*, and the angular point oppoſite to the baſe, is called the *vertex*.

17. In a right-angled triangle, the ſide oppoſite to the right angle is called the *hypothenuſe*.

18. A plane of four ſides, is called in general a *quadrilateral* figure.

19. A quadrilateral, whoſe four ſides are equal as well as the four angles, is called a *ſquare*, as A.

20. If the four angles are equal, and only the oppoſite ſides a *rectangle*, as B.

21. If the oppoſite angles are only equal, and the oppoſite ſides a *parallelogram*, as C.

22. A plane figure of above four ſides, is called in general a *polygon*.

23. A *circle* is a plane figure bounded by one continued line ABC called the *circumference*, which is every where equally diſtant from a point O within the circle, called the *center*.

24. Any line, as AO, drawn from the center to the circumference, is called a *radius*.

25. Any line, as AB, terminating in a circle, is called a *chord*, which divides the circle into two parts, ABC, ADB, called *ſegments*; the parts of the circumference, terminated by the chord, are called *arcs*, and when the chord paſſes through the center, it is called a *diameter*, and divides the circle into two equal parts, called *ſemicircles*.

26. Any part of the circle, as AOB, terminated by two radii and an arc, is called a *ſector*.

27. The meaſure of an angle is the arc deſcribed from the angular point as center with any radius, and terminated by the lines which form the angle.

28. A line AT, which touches a circle in one point A only, is called a *tangent*; and the point A, where it touches, the point of *contact*.

29. The line CT drawn from the center and terminated by the tangent, is called the

ſecant

ſecant of the arc AM, as AT is called its *tangent*, and the perpendicular PM to the radius CA the *ſine*, CP the *coſine*, and AP the *verſed ſine* of that arc, or of the arc BM, its ſupplement to a ſemi-circle.

30. A polygon is called *regular*, when all its ſides are equal as well as all its angles; and *irregular*, when they are unequal.

31. A polygon is ſaid to be *inſcribed* in a circle, when all its angles touch the circumference; and *circumſcribed* about a circle, when all its ſides touch the circle.

Polygons are diſtinguiſhed by the number of their ſides, viz.

5	Pentagon.	9	Enneagon.
6	Exagon.	10	Decagon.
7	Eptagon.	11	Ondecagon.
8	Octagon.	12	Dodecagon.

Problems uſeful in Fortification.

1. *To draw a line, through a given point* C, *perpendicular to another line* AB.

From the given point C as center, deſcribe an arc with any radius ſo as to meet the line AB, in two points E,F, and from theſe points as centers, deſcribe two arcs with the ſame

radius, ſo as to interſect each other at D; then the line drawn through this interſection and the given point C will be the perpendicular required.

2. *To draw a line, through a given point* C, *parallel to another line* AB.

From the given point C as center, deſcribe an arc ſo as to touch the line AB, and from any point E in AB as center, deſcribe another arc with the ſame radius; then the line drawn through the given point C, ſo as to touch this arc, will be the parallel required.

3. *To divide a given line* AB, *into any number of equal parts, as five.*

Through the extremity A draw a line AC at pleaſure ſo as to make any angle with AB, and through the other extremity B, draw BD parallel to AC: then if from the point A towards C, there be ſet off as many equal parts leſs one of any length, on AC, as the line AB is to be divided into, and the ſame thing to be done on the line BD; the lines which join the oppoſite points will divide the line AB into the deſired number of equal parts.

4. *To divide a given angle* ACB *into two equal parts.*

From

From the angular point C as center, describe an arc with any radius, meeting the legs of the angle at A, B: from these points as centers, describe two arcs with the same radius, so as to intersect each other at D; then the line drawn through this intersection and the angular point C, will bisect the given angle.

5. *To draw a line* CA, *so as to make an angle* ACB, *with a given line* CB, *equal to a given angle* a c b.

From the points C, c, as centers, describe two arcs with the same radius taken at pleasure: make the arc AB equal to the arc a b; and the line drawn through the points C, A, will make the angle required.

N. B. Mathematicians suppose the circumference of a circle to be divided into 360 equal parts called degrees, each degree divided into 60 equal parts called minutes, as likewise each minute into 60 equal parts called seconds.

These divisions are generally marked on a brass semi-circle or a rectangular piece of ivory, called protractor, and serve either to measure any angle by, or to lay down any angle on paper.

Hence a quadrant or the measures of a right angle is 90 degrees, as being the fourth

part of the circumference; a ſemi-circle or the meaſure of two right angles 180; and becauſe the three angles of a triangle being equal to two right ones, each of the angles of an equilateral triangle, is one third of 180; that is, 60 degrees, or the ſixth part of the whole circumference.

6. *To biſect a line* AB, *by a perpendicular to it.*

From the extremities A, B, as centers, deſcribe arcs on both ſides of that line, with any radius ſo as to interſect each other at D, and E; then the line DF will be perpendicular to and biſect AB.

7. *To deſcribe the circumference of a circle, through three given points* A, B, C.

Join theſe points by two lines AB, BC; biſect theſe lines by the perpendiculars DO, EO; then their interſection O, will be the center of the circle deſired.

8. *To inſcribe a ſquare in a circle.*

Draw the diameter AB, to which draw the diameter CD perpendicular; then the lines joining the extremities of theſe diameters will be the ſquare ABCD required.

If the quadrant AC be biſected in E, the chord AE or EC will be the ſide of an octagon, inſcribed in the circle.

9. *To*

9. *To inſcribe a pentagon or a decagon in a circle.*

Draw the radius DC at right angles to the diameter AB, biſect AC in E, and from the point E as center, deſcribe an arc through the point D meeting the diameter AB in F, draw DF; then will DF be the ſide of the pentagon, and CF that of the decagon inſcribed in the circle.

10. *To inſcribe an exagon in a circle.*

Take the radius AO and carry it round the circumference, and you will have the exagon required.

If the arc AB be biſected at D, the chord of the arc AD or DB, will be the ſide of a dodecagon inſcribed in the circle.

N. B. The eptagon, enneagon, and ondecagon, cannot be geometrically inſcribed in a circle; for which reaſon we ſhall give mechanical conſtructions of them, which are ſufficiently exact for practice.

11. *To inſcribe an eptagon in a circle.*

From any point A in the circumference as center, deſcribe an arc through the center O, meeting the circumference in B and C; draw CB and the radius AO; then the half BD or DC of BC will be the ſide of an eptagon nearly.

12. *To inscribe an enneagon in a circle.*

Carry the radius from A to B, and divide the arc AB into three equal parts, by repeated trials; and let A a be two thirds of AB; then the chord A a will be the side of the enneagon exactly, if A a is exactly two two thirds of AB.

13. *To inscribe an ondecagon in a circle.*

Draw the radius CD, perpendicular to the diameter AB; from the extremity B as center, describe an arc through the point D, meeting the diameter in E, at E erect a perpendicular EF, to the diameter, or draw EF parallel to CD, meeting the circumference in F: then if the arc A F be bisected in G, the chord of AG or GF will be the side of the ondecagon required.

14. *To inscribe a polygon in a circle, so that its sides shall be of a given length.*

Inscribe a similar polygon, that is, one of the same number of sides, in any circle by the foregoing problems; and let AB be one of those sides, which produce to C so as BC be equal to the given side, and draw CD parallel to the radius OB, till it meets the radius OA produced at D; then OD will be the radius of the circle required.

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Of the measures and scales used in Fortification.

The *French* make use of a measure called a *toise*, which is six feet, and therefore, is what we call a *fathom* here in *England*.

The *Dutch*, and most of the *Germans* make use of the *Rhinland rod*, which is 12 Rhinland feet.

The *French* royal foot is to the *English* foot, as 114 to 107, or as 16 to 15 nearly, in smaller numbers.

The Rhinland foot is to the *French* foot, as 1033 to 1068, or as 29 to 30 nearly, in smaller numbers; and therefore, half the Rhinland rod is to a *French* toise, as 29 to 30 nearly.

As we propose to give M. *Vauban*'s constructions, with those of the most celebrated authors of that nation, we shall use the word toises in this work, as being more convenient for understanding their methods than that of fathom; the valuation of the *French* into *English* measure, may be easily made by the proportion given above.

When a plan of a fortification is to be drawn, which is to be executed, it will be con-

convenient to have a ſcale divided into equal parts; as for example, an inch divided into 20, 25, 30, 35, 40, 45, 50, 55, 60; then that of 40 to an inch is to be uſed in this caſe; in order to expreſs every part diſtinctly, which cannot ſo well be done upon a ſmaller one.

When a plan is to be drawn upon any other occaſion, any other ſcale will do, which may be greater or leſs, according as it is thought moſt convenient.

The profiles are generally drawn upon a ſcale of thirty feet to an inch; becauſe they are to expreſs the heights of the different parts, which cannot ſo well be done upon a leſſer.

If a ſcale ready divided cannot be had, or ſuch a one as may be wanted upon a particular occaſion, there muſt be one made on ſtrong paper, by the help of the third problem.

Colours uſed in the drawings of Fortifications.

It is neceſſary to uſe colours in the drawings of plans and profiles of a fortification, in order to diſtinguiſh every particular part, and ſeparate, as it were, the one from the other, ſo

ſo as to make their difference more ſenſible. The manner of uſing colours, is called *colouring*.

The firſt and moſt neceſſary thing required in drawing, is *Indian ink*; for it ſerves, in drawing the lines, to expreſs hills or riſing grounds, and in ſhort, for all what is called ſhading in drawings.

There are ſix different ſorts of colours, generally uſed in theſe kinds of drawings, viz. *carmine*, *verdegreaſe*, *ſap-green*, *gum-bouch*, *indigo*, and *umber*.

The beſt ſort of Indian ink is of a bluiſh black, ſoft, and eaſily reduced into a liquid, free from ſand or gravel: it is ſold in ſticks from three pence a ſtick to half a crown, according to its goodneſs and quantity.

The manner of liquefying it is by putting a little clear water into a ſhell or tea-cup, and rubbing it gently till the water is black, and of a conſiſtence much like common ink; when it is uſed for drawing lines, it muſt be made very black, though not too thick, otherwiſe it will not eaſily flow out of the drawing pen: but when it is for ſhading, it muſt be pale, ſo as to go over the ſame ſhade ſeveral times, which will make it look much finer and ſofter than if it was done at once.

Carmine

Carmine is in powder, and the fineſt red we know of; it ſerves for colouring the ſections of maſonry, the plans of houſes and other buildings; as likewiſe their elevations, but is then made of a paler colour.

This colour is alſo uſed for drawing red lines in plans, to repreſent walls: it is very dear, being generally a guinea an ounce, but a little goes a great way.

The verdegreaſe uſed in drawings, which is commonly called *ſea-green*, is liquid, and ſold in little vials for ſix pence a-piece; it ſerves to colour wet ditches, rivers, ſeas, and in general to repreſent all watry places.

Sap-green is in ſtone, of a yellowiſh green, when liquefied with clear water; but when it is mixt with ſome ſea-green, it makes a fine graſs-green; as all mixt colours are liable to fade, if *verd'iris* can be had, it will be much better; ſap-green is very cheap, for two or three pence, one may have as much as will ſerve a great while.

Gum-bouch is a fine yellow in ſtones, and very cheap; it ſerves to colour all projects of works; as likewiſe to diſtinguiſh the works unfiniſhed from thoſe that are ſo. It ſerves alſo to colour the trenches of an attack.

This

This colour is prepared, by taking water in a hair pencil, and rubbing it gently, then putting it in a shell, and this is repeated till the colour is as strong as is necessary.

Indigo is in small cakes, and very cheap; it serves to colour iron and roofs of buildings, which are covered with slates: it must be well ground upon a smooth stone or glass, and then mixt with a little gum-water.

If the sea-green is too pale, by mixing a little indigo with it, it will make a fine bluish colour.

Umber is a yellowish brown colour in powder; when it is mixt with gum-water, it serves to colour dry ditches, sand, and all things of earth. By mixing a little red ink with it, it will also make a wood colour. If some tobacco leaves are steept in clear water for some hours, and filtered through a woollen cloth, or brown paper, with a little red ink mixt in it, it makes the best earth or wood colours, as lying smoother than any other.

In drawing encampments, it is necessary to have a fine blue, to represent the colour of blue cloth; *smalt*, sold in shells for about a groat a-piece, is very good for that purpose, or else *Prussian blue*, well ground and mixt with a little gum-water.

Gum-water is beſt when it is made ſome time before it is uſed; for which reaſon, take ſome gum-arabic, and ſteep it in clear water for ſome hours till it is diſſolved; then ſtrain it through a woollen cloth or brown paper, and preſerve it in a vial, well ſtopped, that no dirt can come into it, till it is wanted.

SECTION II.

Of regular Fortification.

FOrtification, is the art of incloſing towns with works in ſuch a manner, as that a ſmall number of men may reſiſt, for ſome time, a conſiderable army.

The attack of a place, is the art of making and conducting all the different works in a ſiege, in order to become maſter of the place.

And the defence of a place, is the art of defending a town beſieged, with all the advantages that the fortification will admit of.

The art of fortification may be diſtinguiſhed into two parts, *viz.* the elementary or theoretical, and practical.

The

The elementary part conſiſts in teaching the plans and profiles of a fortification on paper, with ſcales and compaſſes; and to examine the ſyſtems propoſed by different authors, in order to diſcover their advantages and diſadvantages.

And the practical part conſiſts in forming a project of a fortification, according to the nature of the ground and other neceſſary circumſtances, to trace it on the ground, and to execute the project, together with all the military buildings, ſuch as magazines, ſtorehouſes, bridges, *&c.*

It is the elementary part which we propoſe to treat of in this work, reſerving the other for a ſecond volume, which we ſhall divide into regular and irregular fortification; but before we enter any farther upon the ſubject, it will not be diſagreeable to beginners to ſay ſomething concerning the riſe and progreſs of fortification.

The origin and riſe of fortification is undoubtedly owing to the degeneracy of mankind; for in the firſt ages of the world, men were diſperſed up and down the countries in ſeparate families, as we are told in the hiſtories of the Jews and Scythians, who wandered from one place to another for the ſake of find-

ing paſture for their cattle. Theſe families became in time ſo numerous as to form large communities, which ſettled all together in a place; from whence villages and towns had their origin and riſe: but they found it was neceſſary, for the common ſecurity, to ſurround thoſe towns with walls and ditches, to prevent all violences, *and ſudden ſurprizes from their neighbours*. This was ſufficient for ſome time, till offenſive weapons were invented, and conquering became a faſhion; then walls with loop-holes were made at proper diſtances, in order to ſcreen the defenders againſt the arrows of the aſſailants; but finding that as ſoon as the enemy got once cloſe to the walls, they could from no part be diſcovered or repulſed; for this reaſon they added ſquare towers at proper diſtances from each other, ſo that every part of the wall might be defended by the adjacent ſides of the towers. However, this manner of incloſing of towns was found to be imperfect, becauſe there remained ſtill one of the faces of the towers which fronted the field that could not be ſeen from any other part, and therefore could not be defended. To remedy this, they made the towers round inſtead of ſquare, imagining this figure to be the ſtrongeſt to reſiſt the

the battering engines, as likewise to be better defended from the other parts of the wall.

Notwithstanding the superiority of this method above the former, there remained yet a part of these towers unseen and uncapable to be defended; which made them change the figure of the towers again; that is, they made them squares as before; but instead of presenting a face to the field as formerly, they presented an angle; by this means they effectually found out such a disposition of their works, that no part could be attacked without being seen or defended by some other part.

This last method was in use a long while, and would in all appearance have continued to this day, if gunpowder had not been found out: but the violence of the guns and mortars soon convinced the world, that such towers and walls were but a weak defence against these thundering engines; and besides, as the nature of the attack was entirely changed, it was also necessary to change that of fortifying likewise.

From that time, ramparts were added to the walls, the towers enlarged into bastions, and all sorts of outworks have been added, such as ravelins, counterguards, horn and

crown-works, and others of the like nature, in order to render the defence in some measure equivalent to the attack.

Notwithstanding all the improvements which have been made in the art of fortifying since the invention of gunpowder, that of attacking is still superior to it. Engineers have tried in vain to render the advantages of a fortification equal to those of the attack; the superiority of the besiegers fire, together with the greater number of men, obliges generally, sooner or later, the besieged to submit.

The greatest improvement made in the art of attacking happened in the year 1697, when M. *Vauban* made first use of ricochet firing at the siege of *Ath*, whereby the besieged, placed behind the parapets, were as much exposed to the fire of the besiegers, as if there had been none; whereas before, they had been secure as long as the parapet was not demolished: and the worst is, that there can be no remedy found to prevent this enfilading, without falling into inconveniencies almost as bad as those which we endeavour to avoid.

Although authors agree as to the general form in the present manner of fortifying, yet they mostly differ in particular constructions of the parts: as it would be both needless and

and superfluous to treat of all the different methods hitherto proposed, we shall content ourselves with explaining those only, which are most esteemed by the best judges, and have been mostly put in practice; with adding observations on their perfections and imperfections, and point out how some of the parts may be improved.

As M. *Vauban* had more experience than any other engineer whatsoever, and his methods are mostly used all over *Europe*, we presume it will be more advantageous to beginners to explain his methods first; and then those of Mr. *Coehorn*, who, next to M. *Vauban*, excelled in this art.

M. *Vauban* has given three different methods; the first is that which has been used in the fortifying of most places; the second was used at *Landau* and *Beford*, chiefly designed for places which have a wall or rampart already; and the third has been applied in the fortifying of *New Brisach*; each of these methods will be treated of separately, in their order.

Construction of M. VAUBAN's *first Method.*

This method is divided into little, mean, and great; the little is chiefly used in the

conſtruction of citadels, the mean in that of all ſorts of towns, and the great in particular caſes only.

We ſhall give the conſtruction of the mean, as being moſt uſeful, and refer the reader to the table hereafter, for thoſe dimenſions which are different in theſe ſeveral fortifications.

Plate I. Fig. 1. Inſcribe in a circle a polygon of as many ſides as the fortification is deſigned to have fronts; let AB be one of the ſides of half an exagon, which biſect by the perpendicular CD: divide half AC of it into nine equal parts, and one of theſe into ten others; then theſe diviſions will ſerve as a ſcale to conſtruct all the parts of the fortification, and each of them is ſuppoſed to be a toiſe or fathom, that is, ſix *French* feet; and therefore the whole ſide AB is ſuppoſed to be 180 toiſes.

As the dividing a line into ſo many equal parts, is troubleſome and tedious, it is more convenient to have a ſcale of equal parts, by which the works may be conſtructed.

If therefore, in this caſe, the radius is taken equal to 180 toiſes, and the circle deſcribed with that radius being divided into ſix equal parts, or the radius being carried ſix times round, you will have an exagon inſcribed;

AB

AB being biſected by the perpendicular CD as before, ſet off 30 toiſes from C to D, and draw the indefinite lines ADG, BDF, in which take the parts AE, BH, each equal to 50 toiſes; from the center E deſcribe an arc through the point H, meeting AD in G, and from the center H deſcribe an arc through the point E, meeting BD in F; or which is the ſame, make each of the lines EG, HF, equal to the diſtance EH; then the lines joining the points A, E, F, G, H, B, will be the principal or outline of the front.

If the ſame conſtruction be performed on the other ſides of the polygon, you will have the principal or outline of the whole fortification.

If, with a radius of 20 toiſes, there be deſcribed circular arcs, from the angular points B, A, M, T, and lines are drawn from the oppoſite angles E, H, &c. ſo as to touch theſe arcs, their parts a b, b c, &c. together with theſe arcs, will repreſent the outline of the ditch.

N. B. In any other polygon, beſides the exagon, the radius cannot be equal to 180 toiſes; and in that caſe the radius muſt be found, ſo as to anſwer to a given ſide of 180 toiſes, by Problem 14.

DE-

DEFINITIONS.

1. The part FEALN, is called the *baſtion.*
2. AE, AL, the *faces* of the baſtion.
3. EF, LN, the *flanks.*
4. FG, the *curtain.*
5. FN, the *gorge* of the baſtion.
6. AG, BF, the *lines of defence.*
7. AB, the *exterior ſide of the polygon.*
8. CD, the *perpendicular.*
9. Any line which divides a work into two equal parts, is called the *capital* of that work.
10. abc, the *counterſcarp* of the ditch.
11. A,M, the *flanked angles.*
12. H,E,L, the angles of the *ſhoulder,* or *ſhoulder* only.
13. G,F,N, the *angles* of the *flank.*
14. Any angle whoſe point turns from the place, is called a *ſaliant angle,* ſuch as A,M; and any angle whoſe point turns towards the place, *re-entering angle,* ſuch as b,F,N.
15. If there be drawn two lines parallel to the principal or outline, the one at 3 toiſes diſtance, and the other at 8 from it; then the ſpace yx included between the principal one, and that fartheſt diſtant, is called the *rampart.*

And

And the ſpace xx, contained by the principal line, and that next to it, and which is generally ſtained black, is called the *parapet*.

16. There is a fine line drawn within four feet of the parapet, which expreſſes a ſtep called *banquette*.

N. B. All works have a parapet of three toiſes thick, and a rampart of 8 to 10, beſides their ſlopes. The rampart is elevated more or leſs above the level of the place, from 10 to 20 feet, according as the nature of the ground is, and according to the particular conſtructions of engineers.

The parapet is a part of the rampart elevated from 6 to $7\frac{1}{2}$ feet above the reſt, in order to cover the troops, which are drawn up there, from the fire of the enemy in a ſiege; and the banquette is two or three feet higher than the rampart, or about four feet lower than the parapet; ſo that when the troops ſtand upon it, they may juſt be able to fire over the parapet.

17. The body of the place, is all that which is contained within this firſt rampart; for which reaſon, it is often ſaid to conſtruct the body of the place; which means properly, the conſtruction of the baſtions and curtains.

18. All

18. All the works which are conſtructed beyond the ditch, before the body of the place, are called *outworks.*

TABLE.

	Forts.						Little Fortif.				Mean		Great	
Side of Polyg.	80	90	100	110	120	130	140	150	160	170	180	190	200	260
Perpendiculars	10	11	$12\frac{1}{2}$	14	15	16	20	21	23	25	30	31	25	22
Faces baſt.	22	25	28	30	33	35	40	42	45	47	50	53	55	60
Cap. of ravel.	25	28	30	35	38	40	45	50	50	52	55	55	60	50

In the firſt vertical column are the numbers expreſſing the lengths of the exterior ſides from 80 to 260.

In

In the ſecond, the perpendiculars anſwering to theſe ſides.

In the third, the lengths of the faces of the baſtions; and in the fourth, the lengths of the capitals of the ravelins.

The forts are moſtly, if not always, ſquares, for which reaſon, the perpendiculars are made one eighth of the exterior ſides; becauſe, if they were more, the gorges of the baſtions would become too narrow.

The little fortification, is chiefly deſigned for citadels, and are commonly pentagons; the perpendiculars are made one ſeventh of the exterior ſide; the mean is uſed in all kinds of fortifications, from an exagon upwards to any number of ſides; and the great is ſeldom uſed but in an irregular fortification, where there are ſome ſides that cannot be made leſs without much expence; or in a town which lies near a great river, where the ſide next the river is made from 200 to 260 toiſes; and as that ſide is leſs expoſed to be attacked than any other, the perpendicular is made ſhorter, which ſaves much expence.

The faces of the baſtions are all $\frac{2}{7}$ths of the exterior ſides, or nearly ſo, becauſe the fractions are neglected.

It

It may be obſerved in general, that in all ſquares the perpendicular is $\frac{1}{8}$th of the exterior ſide, in all pentagons $\frac{1}{7}$th, and in all the reſt upwards $\frac{1}{6}$th.

Conſtruction of Orillons and retired Flanks.

Deſcribe the front MPQRST as before, and divide the flank into three equal parts, of which ſuppoſe S r to be one: from the oppoſite flanked angle M, draw a line M r, in which take the part m r of 5 toiſes; take likewiſe R n in the line of defence MR, produced, equal to 5 toiſes, and join n m, upon which as a baſe deſcribe the equilateral triangle n p m, and from the angle p, oppoſite to the baſe as center, is deſcribed the circular flank, n m.

And if S r be biſected by the perpendicular, 1, 2, and another be erected upon the face ST, at S; the interſection 2 of theſe two perpendiculars, will be the center of the arc which forms the orillon.

The orillons are very uſeful in covering the retired flanks, which cannot be ſeen but directly in the front; and as theſe orillons are round, they cannot be ſo eaſily deſtroyed

as

as they would be, if they were of any other figure. But for what reaſon the retired flanks are made of ſuch circular arcs as theſe, is not poſſible to be gueſt at; ſince it may eaſily be proved, as we ſhall do in the third ſection, that the flank made upon the chord of that arc would be much better, and is at the ſame time of leſs expence.

But what is more ſtrange, that moſt engineers look upon theſe flanks as the beſt that could have been thought of, and they uſe them in all fortifications, which they propoſe as the beſt models: there can be given no other reaſon of this opinion, than the unaccountable fancy, of mankind in general, for novelty; and their indolence to receive from others, things for true, rather than to inquire whether they be ſo or not.

Conſtruction of Ravelins or Half-moons.

Set off 50 toiſes, from the re-entering angle Fig. 2. O of the counterſcarp, on the capital OL of the ravelin, or on the perpendicular produced, and from the point L draw lines to the ſhoulders A, B; whoſe parts LM, LN, terminated by the counterſcarp, will be the faces MO, ON, the ſemi-gorges of the ravelin required.

This

This is M. *Vauban's* method of constructing ravelins, according to some authors; and others will have the faces of the ravelin to terminate on those of the bastions within 3 toises of the shoulders; which seems to be the best way, for the ravelins cover the flanks much better than the others.

The ditch before the ravelin is 12 toises, its counterscarp parallel to the faces of the ravelins, and is made in a circular arc, before the saliant angle; as likewise all ditches are in general.

When the ravelins are made with flanks, as in figure 3, the faces should terminate of those of the bastions, at least 5 toises from the shoulders.

The flanks are made by setting of 10 toises from the extremities of the faces, from f to h, and from m to l, and from the points h, l, the flanks h k, l p, are drawn parallel to the capital LO of the ravelin.

There are sometimes redoubts made in the ravelin, such as in fig. 2. which is done by setting of 16 toises from the extremities of the faces on the semi-gorges from N to b, and from M to a; and from the points b, a, the faces are drawn parallel to those of the ravelin: the ditch before this redoubt is 6 toises, and its counterscarp parallel to the faces.

Con-

Construction of Tenailles.

A tenaille is a work made in the ditch before the curtains, the parapet of which is only 2 or 3 feet higher than the level ground of the ravelin. There are three different sorts; the first are those as in fig. 1, which are made in the direction of the lines of defence, leaving a passage of 3 toises between their extremities and the flanks of the bastions, as likewise another of 2 in the middle for a bridge of communication to the ravelin. Plate II. Fig. 1, 2, 3.

The second sort, are those as in fig. 2.; their faces are in the lines of defences, and 16 toises long, besides the passage of 3 toises between them and the flanks of the bastions; their flanks are found by describing arcs from one shoulder of the tenaille as center through the other, on which are set off 10 toises for the flanks desired.

And the third sort, are those as in fig. 3; their faces are 16 toises, as in the second sort, and the flanks are parallel to those of the bastions.

The use in general of tenailles, is to defend the bottom of the ditch by a grazing

 fire,

fire, as likewiſe the level ground of the ravelin, and eſpecially the ditch before the redoubt within the ravelin, which can be defended from no where elſe, ſo well as from them.

The firſt ſort do not defend the ditch ſo well as the others, as being too oblique a defence; but as they are not ſubject to be enfiladed, M. *Vauban* has generally preferred them in the fortifying of places, as may be ſeen in the citadel of *Lille*, at *Landau*, *New Briſach*, and in a great many other places.

The ſecond ſort defend the ditch much better than the firſt, and add a low flank to thoſe of the baſtions; but as theſe flanks are liable to be enfiladed, they have not been much put in practice. This defect might however be remedied, by making them ſo, as to be covered by the extremities of the parapets of the oppoſite ravelins, or by ſome other work.

As to the third ſort, they have the ſame advantage as the ſecond, and are likewiſe liable to the ſame objections; for which reaſon they may be uſed with the ſame precautions, which have been mentioned in the ſecond.

Tenailles

Tenailles are eſteemed ſo neceſſary, that there is hardly any place fortified without them, and it is not without reaſon; for when the ditch is dry, the part behind the tenailles ſerves as a place of arms, from which the troops may ſally, deſtroy the works of the enemy in the ditch, oppoſe their deſcent, and retire with ſafety; and the communication from the body of the place to the ravelin becomes eaſy and ſecure, which is a great advantage; for by that means the ravelin may make a much better defence, as it can be ſupplied with troops and neceſſaries at any time. And if the ditch is wet, they ſerve as harbours for boats, which may carry out armed men to oppoſe the paſſage over the ditch whenever they pleaſe; and the communication from the tenailles to the ravelin, becomes likewiſe much eaſier than it would be without them.

Conſtruction of Lunettes.

Lunettes are placed on both ſides of the ravelin, ſuch as B, to increaſe the ſtrength of a place; they are conſtructed, by biſecting the faces of the ravelin with the perpendicular LN, on which is ſet off 30 toiſes from the Fig. 4.

 coun-

counterſcarp of the ditch, for one of its faces; the other face PN, is found by making the ſemi-gorge TP of 25 toiſes; the ditch before the lunettes is 12 toiſes, the parapet 3, and the rampart 8; as in the ravelin.

There is ſometimes another work made to cover the ſaliant angle of the ravelin, ſuch as A, called *Bonnet*, whoſe faces are parallel to thoſe of the ravelin, and when produced biſect thoſe of the lunettes; the ditch before it is 10 toiſes.

Fig. 5. There are likewiſe lunettes, ſuch as D, in fig. 5, whoſe faces are drawn perpendicular to thoſe of the ravelin, within a third part from the ſaliant angle; and their ſemi-gorges are only 20 toiſes.

Theſe kind of works may make a good defence, and are no very great expence; for as they are ſo near the ravelin, the communication with it is very eaſy, and one cannot well be maintained, till they are all three taken.

I would have the face PN (fig. B) perpendicular to that of the baſtion, which would then defend it in a direct manner; and if the ſemi-gorges of the bonnet A were only 7 or 8 toiſes, it would become leſs expenſive, and its ditch and the covert-way before it would be better defended by the lunettes.

Con-

Construction of Tenaillons.

Produce the faces of the ravelin beyond the counterscarp of the ditch, at a distance MN of 30 toises, and take on the counterscarp of the great ditch, 15 toises from the re-entering angle p to q, and draw Nq; then qNMp will be the tenaillon required; its ditch is 12 toises, that is, the same as that of the ravelin. Sometimes there is made a retired battery, in the front of the tenaillons, as in fig. B; this battery is 10 toises from the front to which it is parallel, and 15 toises long. Fig. 6.

There are commonly retrenchments made in the tenaillons, such as O; their parapets are parallel to the fronts MN, or rather perpendicular to the side Nq, and bisect the side qN; the ditch before this retrenchment is 3 toises, and there is a banquette before the parapet, next to the ditch, of about 8 feet, called *Berm*; it serves to prevent the earth of the parapet (which seldom has any revetement) from falling into the ditch.

It is to be observed, that the ravelin, before which tenaillons are constructed, must have its saliant angle much greater than the former construction makes them; otherwise the

the ſaliant angles of the tenaillons become too acute, for which reaſon we made the capital of this ravelin 45 toiſes, and the faces terminate within 3 toiſes of the ſhoulders.

Conſtruction of Counterguards.

Plate III. Fig. 1, 2. When the counterguard is placed before the ravelin, ſet off 40 toiſes on the capital of the ravelin from the ſaliant angle A, to the ſaliant angle B, of the counterguard; and 10 from C to D, on the counterſcarp of the ditch.

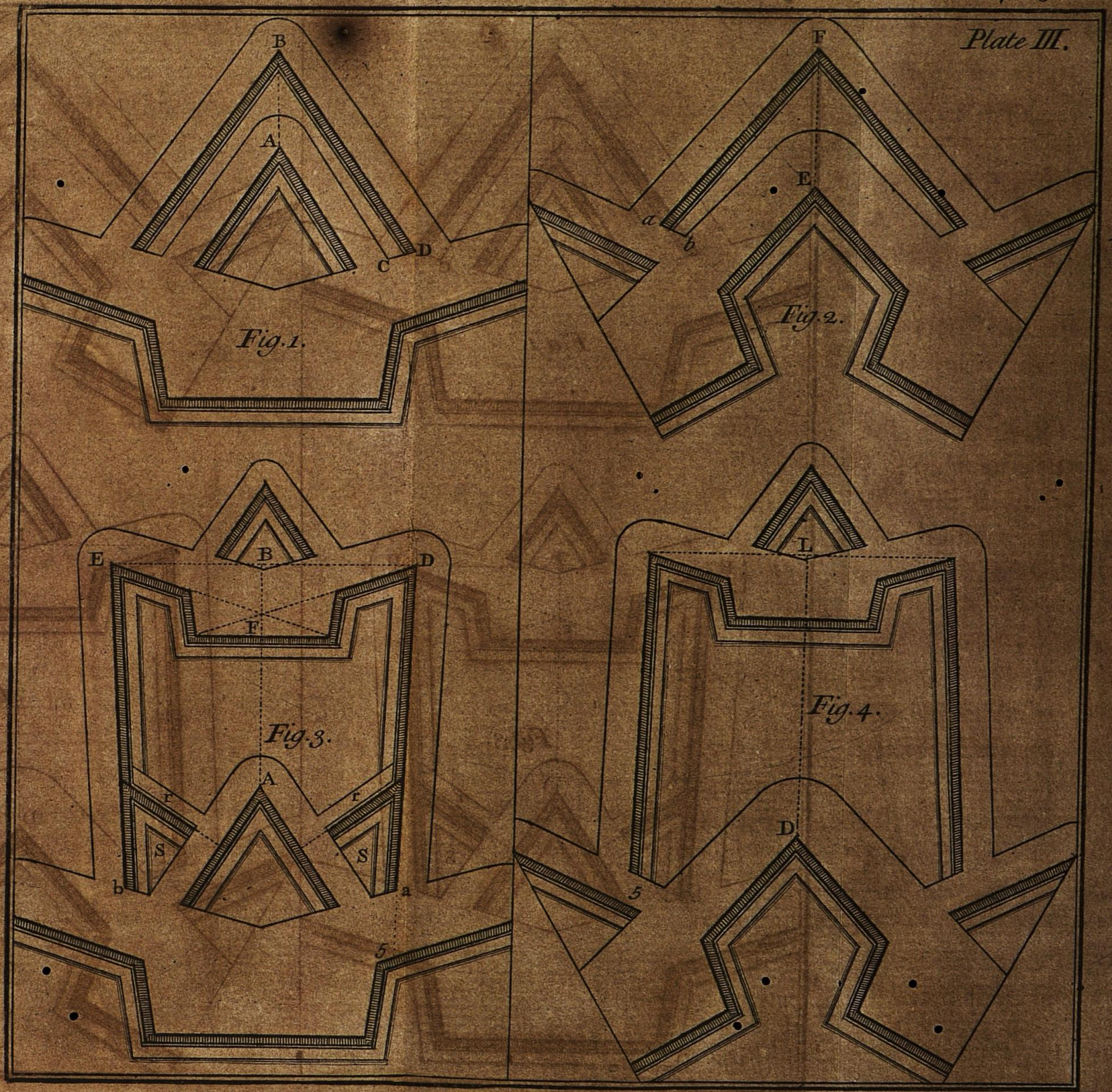
When the counterguard is before the baſtion, ſuch as in fig. 2, its ſaliant angle F is 50 toiſes from the ſaliant angle E of the baſtion, and the breadth near the ditch of the ravelin is 10 toiſes as before.

The ditch before the counterguards is 12 toiſes, and its counterſcarp parallel to the faces.

Counterguards are made before the ravelin, in ſome particular occaſions only, but are frequently conſtructed before the baſtions; as covering the flanks wonderfully well. Some authors, as *Blondel*, and M. *Coehorn*, will have them much narrower than they are here.

Con-

Plate III.



Construction of Hornworks.

Produce the capital of the ravelin beyond the ſaliant angle A, at a diſtance AB of about 80 toiſes; draw DBE, at right angles to AB; in which take BD, BE, each equal to 55 toiſes; and on the exterior ſide DE, trace a front of a polygon in the ſame manner as that of the body of the place, making the perpendicular BF 18 toiſes; and the faces 30. Fig. 3.

The branches Da, Eb, of the hornwork, when produced, terminate on the faces of the baſtions, within 5 toiſes of the ſhoulders. The ditch of the hornwork is 12 toiſes, and its counterſcarp parallel to the branches; and in the front terminates at the ſhoulders, in the ſame manner as the great ditch before the baſtions.

The capital of the ravelin before the front of the hornwork is 35 toiſes, and the faces terminate on the ſhoulders, or rather 2 or 3 toiſes beyond them: and the ditch before the ravelin is 8 toiſes.

There are ſometimes retrenchments made within the hornwork, such as S, S; which are conſtructed by erecting perpendiculars to the

the faces of the ravelins, within 25 toiſes of their extremities. This retrenchment, like all others, has a parapet turfed only with a berm of 8 feet before it; as likewiſe a ditch from 3 to 5 toiſes broad.

Fig. 4. When a hornwork is made before the baſtion; the diſtance DL, of the front from the ſaliant angle of the baſtion, is 100 toiſes; and the branches terminate on the faces of the adjacent ravelins within 5 toiſes from their extremities; all the reſt the ſame as before.

Conſtruction of Crownworks.

Plate IV. Fig. 1. From the ſaliant angle A of the ravelin, as a center, deſcribe an arc of a circle with a radius of about 120 toiſes, cutting the capital of the ravelin produced at C; from the point C ſet off the cords CB, CF, each of them equal to 110 toiſes, and on each of which, as an exterior ſide, conſtruct a front of a polygon of the ſame dimenſions as in the hornwork; that is, the perpendicular ſhould be 18 toiſes, the faces 30, and the branches terminate on the faces of the baſtions, within 25 toiſes of the ſhoulders.

The ditch is 12 toiſes, the capital of the ravelin 35, and its ditch 8; that is, the ſame as in the hornwork. Some-

Plate IV.

Sometimes the crownwork is made before the baſtion, as in fig. 2; the arc is deſcribed from the ſaliant angle A, of the baſtion, with a radius of 120 toiſes, as before, and the branches terminate on the faces of the adjacent ravelins, within 25 toiſes of their extremities; the reſt of the dimenſions and conſtructions are the ſame as before. Fig. 2.

Hornworks, as well as crownworks, are never made, but when a large ſpot of ground falls beyond the fortification, which might be advantageous to an enemy in a ſiege, or to cover ſome gate or entrance into a town; they have notwithſtanding been uſed without judgment in ſeveral places, as at *Tournay*, *Ipres*, &c. Their advantages and diſadvantages ſhall be fully diſcuſſed in the third ſection.

Conſtruction of Covert-ways and Glacis.

Although we have not hitherto mentioned the covert-way, nevertheleſs, all fortifications whatſoever have one; for they are eſteemed to be one of the moſt eſſential parts of a modern fortification; and it is certain, the taking the covert-way, when it is in good condition and well defended, is generally

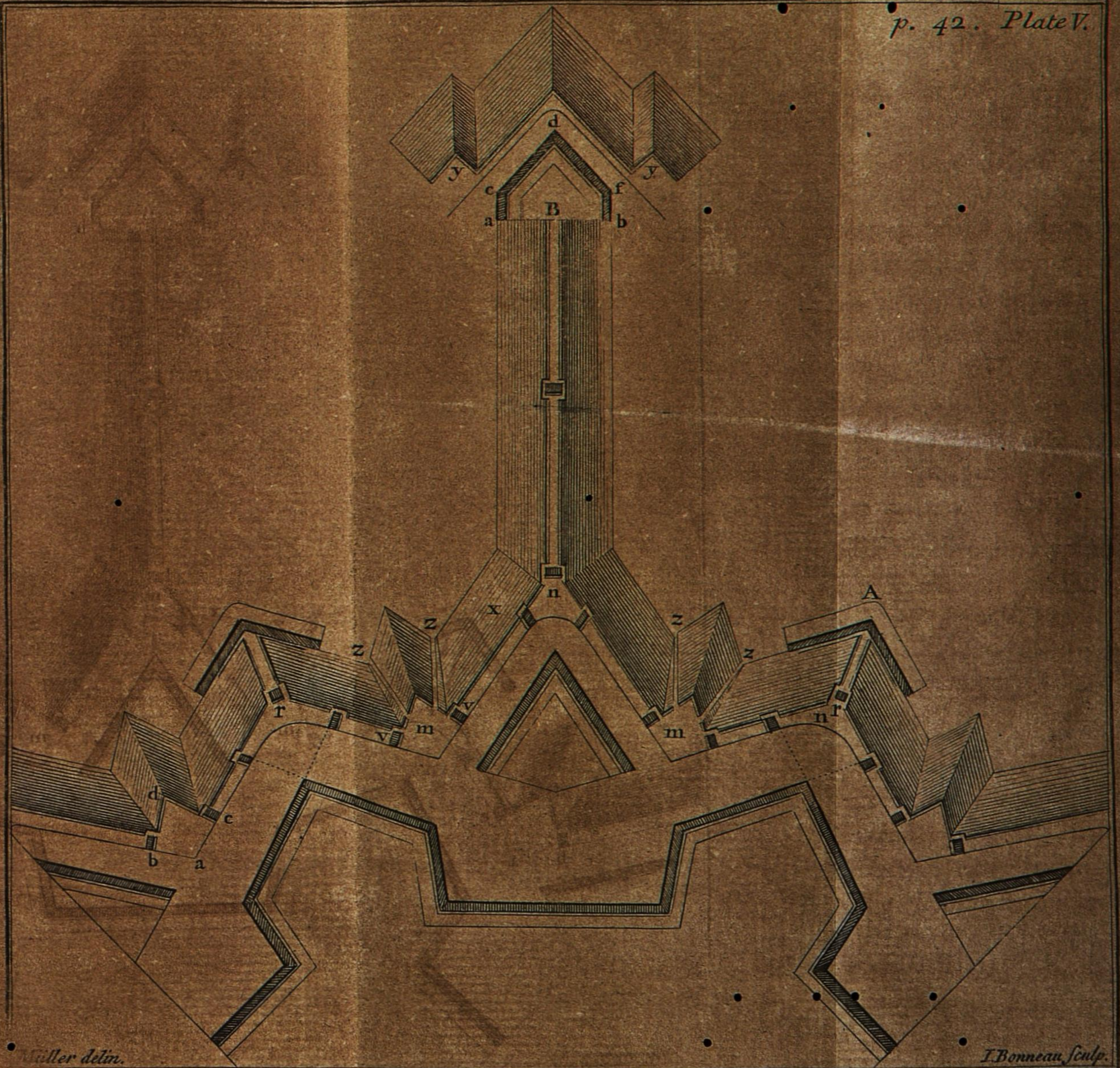
generally the moſt bloody action of the ſiege.

Plate V. After having conſtructed the body of the place, and all the outworks which are thought neceſſary, lines are drawn parallel to the outmoſt counterſcarps of the ditches, at 6 toiſes diſtant from it; and the ſpace m n m n, included between that line and the counterſcarp, will be the covert-way required.

There is in every re-entering angle of the counterſcarp a place of arms, m; which is found by ſetting off 20 toiſes from the re-entering angle a, on both ſides from a to b, and from a to c; and from the points b, c, as centers, arcs are deſcribed with a radius of 25 toiſes, ſo as to interſect each other in d; then the lines drawn from this interſection to the points b, c, will be the faces of the places of arms.

If lines are drawn, parallel to the lines which terminate the covert-way, and the places of arms, at 20 toiſes diſtant from them, the ſpace x,x,x, between theſe lines and thoſe which terminate the covert-way, will be the glacis.

At the extremities of the places of arms, are traverſes made, ſuch as v,v, which ſerve to incloſe them; theſe traverſes are 3 toiſes thick,



Miller delin. I. Bonneau Sculp.

thick, and as long as the covert-way is broad, and a paſſage is cut in the glacis round them, of about 6 or 8 feet, in order to have a free communication with the reſt of the covert-way.

There are alſo traverſes of the ſame dimenſions before every ſaliant angle of the baſtion and outworks, and are in the ſame direction of the faces of thoſe works produced; and the thickneſs lies at the ſame ſide as the parapets.

The paſſages round theſe laſt traverſes are likewiſe from 6 to 8 feet wide.

In each place of arms are two ſally-ports z, z, which are 10 or 12 feet wide, for the troops to ſally out; in time of a ſiege they are ſhut up, with barriers or gates.

Conſtruction of Arrows, and detached Redoubts.

An arrow is a work made before the ſaliant angles of the glacis, ſuch as A; it is compoſed of a parapet of 3 toiſes thick, and 40 long, and the ditch before it 5 toiſes, terminating in a ſlope at both ends. The communication from the covert-way into theſe arrows, is 4 or 5 toiſes wide, and there

there is a traverſe r at the entrance of 3 toiſes thick, with a paſſage of 6 or 8 feet round it.

A detached redoubt is a kind of work much like a ravelin, with flanks, placed beyond the glacis, ſuch as fig. B; they are made in order to occupy ſome ſpot of ground which might be advantageous to the beſiegers; likewiſe to oblige the enemy to open their trenches farther off than they would do otherwiſe.

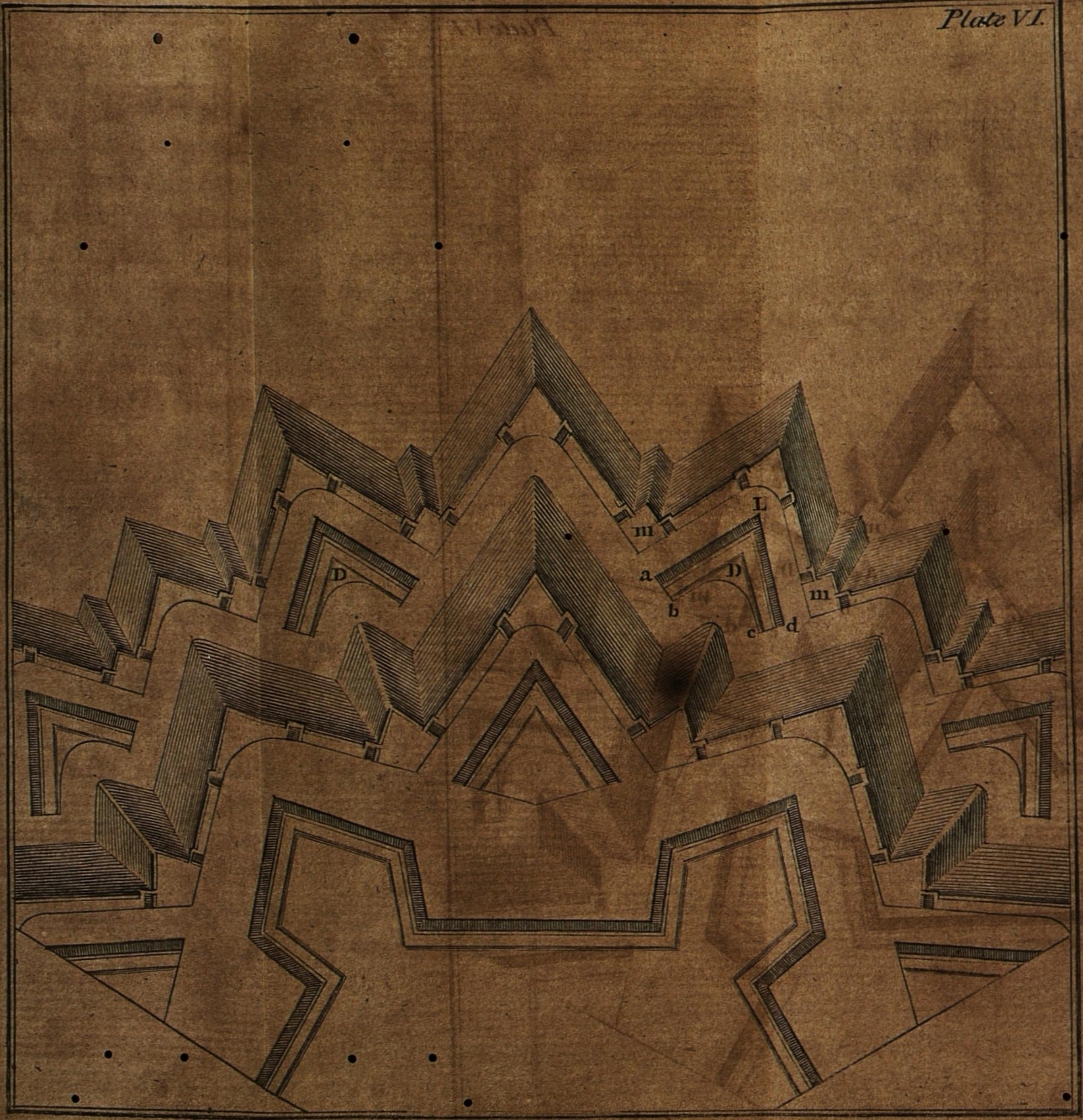
Their diſtance from the covert-way ought not to exceed 120 toiſes, that it may be defended by muſket-ſhot from thence.

The gorge ab is 40 toiſes, the flanks a c, bf, which are perpendicular to the gorge, 10, and the faces cd, fd, 30; the ditch before it is 6 toiſes, ending in ſlopes at both ends; the covert-way 4; the branches of the covert-way are 42 toiſes long, or thereabouts; the faces of the places of arms y, y, which are perpendicular to the branches, 10; and the other, which is parallel to them, 14.

The communication from the covert-way into the redoubt, is 5 or 6 toiſes wide; and there is a traverſe made juſt at the entrance; and another in the middle, when it is pretty long. The parapets of this communication terminate in a ſlope or glacis.

If

Plate VI.



If theſe redoubts are above 50 toiſes diſtant from the covert-way, the beſiegers carry their trenches round, and enter through the gorge; by which the troops that are in them are made priſoners of war, if they do not retire betimes: to prevent this, ſome other outworks ſhould be made to ſupport them.

Conſtruction of ſecond Ditches, and Covert-ways.

When the ground is low, and water to be found, there is often a ditch of about 10 or 12 toiſes made round the glacis; and oppoſite to the places of arms are conſtructed lunettes, beyond the ditch, ſuch as D, whoſe breadth on the counterſcarp of the ditch is 10 toiſes, from b to a, and from c to d, and the faces aL, dL, are parallel to thoſe of the places of arms; the ditch before them is from 8 to 10 toiſes wide. Plate VI.

The ſecond covert-way is 4 toiſes, the ſemi-gorges of the places of arms m about 15, and the faces perpendicular to the counterſcarp; the ſecond glacis is from 15 to 18 toiſes broad.

This ſecond covert-way has traverſes every where, in the ſame manner as the firſt.

Theſe

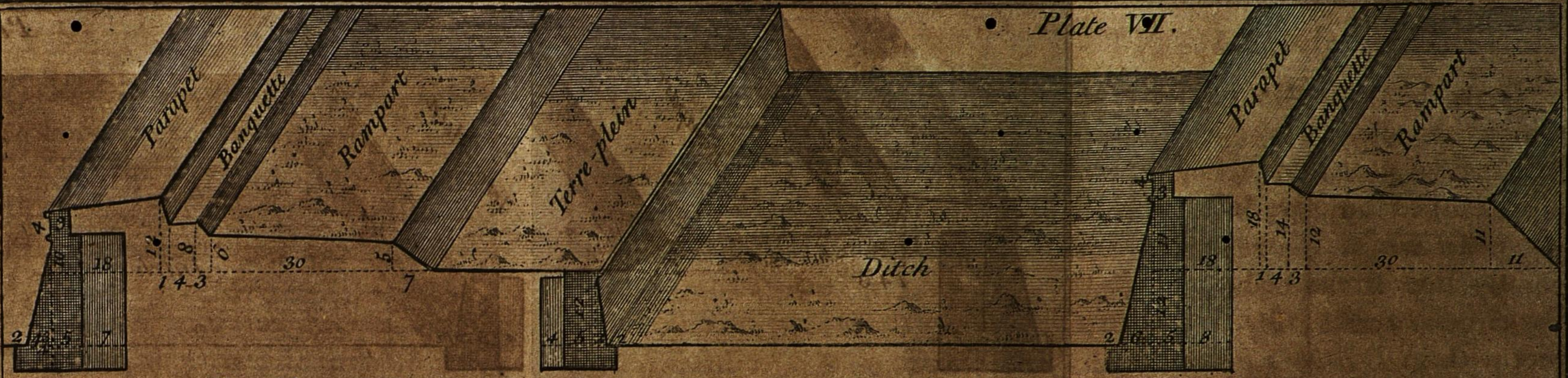
These are nearly all the different outworks, which are used now-a-days, in the construction of places: although they are generally ranked among M. *Vauban*'s works, yet none are of his invention, except the construction of the body of the place, and the circular flanks; for all the rest are to be met with in *Dilichin's Peribologia*, printed at *Frankford* in 1640: and it may be observed, that M. *Vauban* has chiefly copied this author, as *Coehorn* did *Spekel*.

Construction of Profiles.

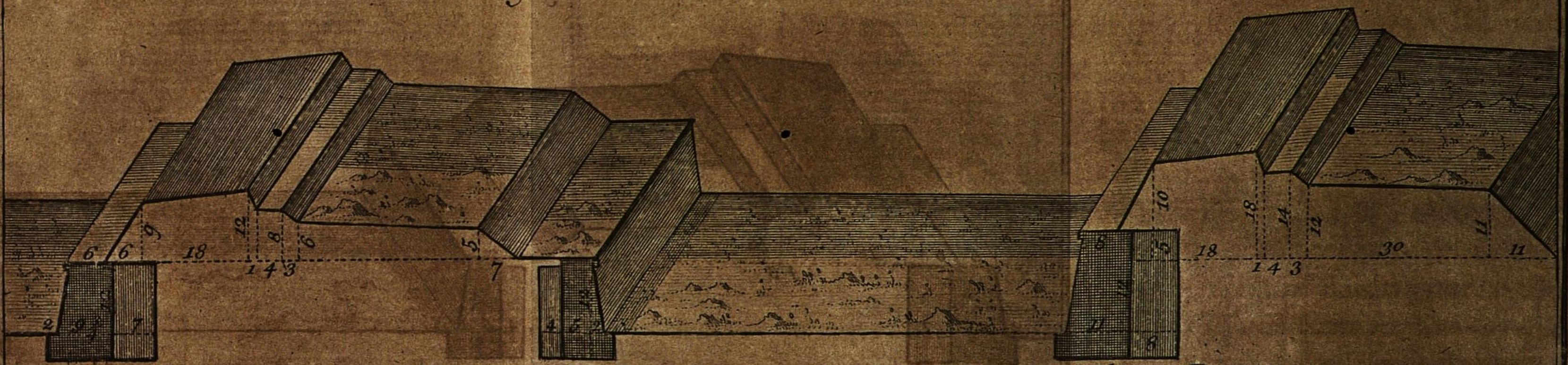
Plate VII. A profile is the representation of a vertical section of a work; it serves to shew those dimensions which cannot be represented in plans, and are necessary in the building of a fortification; they are generally constructed upon a scale of 30 feet to an inch. It would be needless to describe all their particular dimensions, since they are marked in the schemes; we shall therefore lay down the principal rules only, given by M. *Vauban*, on this subject.

1. Every work ought to be at least 6 feet higher than that before it, so that it may command those before it; that is, that the garrison

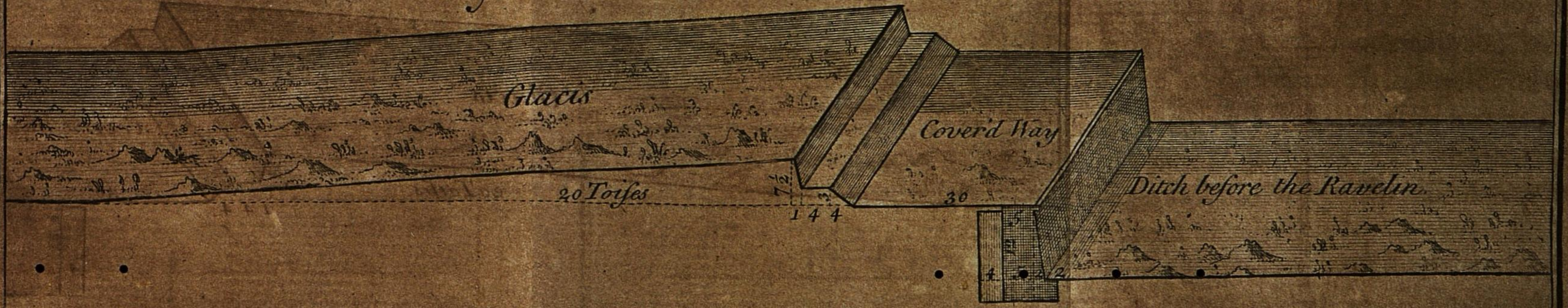
Plate VI.



Profil of the Body of the Place and the Ravelin with Revetement.



Profil of the Body of the Place and the Ravelin with demi-Revetement.



garriſon may fire from all the works at the ſame time, with great and ſmall arms, at the beſiegers in their approaches: notwithſtanding this ſpecious pretence, there are ſeveral authors, who object againſt it. For they ſay, if you can diſcover the enemy from all the works, they can diſcover by the ſame reaſon all the works from their batteries; ſo that they may deſtroy them, without being obliged to change their ſituation, and thereby diſmount all the guns of the place before they come near it.

But if all the works were of the ſame height, thoſe within cannot be deſtroyed, till ſuch time that thoſe before them are taken; guns might be placed in the covert-way and outworks to obſtruct the enemy's approach, and when they come near the place, they might be tranſported into the inner works; and as the body of the place would be much lower, the expence would be conſiderably diminiſhed.

But when works are lower, they are eaſily enfiladed by the ricochet batteries, which is a kind of firing, with a ſmall quantity of powder, by giving the gun an elevation of 10 or 12 degrees: this might, however, be partly prevented, by making the parapets near

near the ſaliant angles, for the ſpace of 8 toiſes on each ſide, five or ſix feet higher than the reſt of the works.

2. The covert-way ſhould be lower than the level ground, otherwiſe the body of the place muſt be raiſed very high, eſpecially when there are ſeveral outworks; this is to be underſtood only when the works exceed each other in height, otherwiſe it need not be below the level.

3. The baſes of all inward ſlopes of earth ſhould be at leaſt equal to the height, if not more.

4. The baſes of all outward ſlopes of earth two thirds of their heights.

5. The ſlopes of all walls or revetements ſhould be one fifth of their height; but one ſixth would be ſufficient in my opinion; the height of a wall is eſtimated from the bottom of the ditch, and not from the beginning of its foundation.

6. The ſlopes of all parapets and traverſes are one ſixth of their breadth; that is, 3 feet towards the field, or the inſide, where the banquettes ſhould be, three feet higher than the outſide.

7. When the revetement of a rampart goes quite up to the top, 4 feet of the upper part

is

is a vertical wall of three feet thick, with a square stone at the top of it, projecting six inches, and a circular one below, or where the slope begins, of 8 or 10 inches diameter; they go quite round the rampart, and the circular projection is called the *Cordon*.

Where the straight part of the wall ends, and the slope begins, the wall is always made five feet thick; and the counterforts or buttresses reach no higher than that place.

8. When the rampart is partly walled and partly turfed, then one fifth of the height which is turfed must be added to five feet, to get the thickness of the wall above.

And having the thickness of any wall above, by adding one fifth of its height from the bottom of the ditch, the sum will be the thickness of the wall at the bottom; but if a sixth part is only taken for the slope, then a sixth part must be added.

For instance, suppose a rampart of 30 feet high from the bottom of the ditch, and that 10 of which are to be turfed; then the fifth part of 10, which is 2, added to 5, gives 7 for the wall above; and as this wall is 20 feet high, the fifth of which is 4, and 4 added to the thickness 7 above, gives 11 for the thickness near the foundation.

The ſeventh plate repreſents in military perſpective the profiles of the body of a place, the ravelin and covert-way, which gives a clear idea of what is meant by a profile; and from which thoſe of all other works may be eaſily conceived.

M. *Vauban* gives in the following table the dimenſions of walls from 10 to 80 feet high, from 10 to 10 feet.

Height of the wall.	Thickneſs above.	Thickneſs below.	Diſtances between the centers of the counter-forts.	Diſtances between the centers of the counter-forts.	Length of the counter-forts.	Thickneſs near the wall.	Thickneſs at the other end.
10	5	7	18	15	4	3	2 : 0
20	5	9	18	15	6	4	2 : 8
30	5	11	18	15	8	5	3 : 4
40	5	13	18	15	10	6	4 : 0
50	5	15	18	15	12	7	4 : 8
60	5	17	18	15	14	8	5 : 4
70	5	19	18	15	16	9	6 : 0
80	5	21	18	15	18	10	6 : 8

All theſe numbers are feet, except in the laſt column, which are feet and inches. M. *Vauban* adds, that when the ſtone or brick-

brickwork is very good, the thickneſs of the wall above may be reduced to 4½ feet or 4 only; but when it is bad, it may be increaſed to 5½ feet, and ſometimes more.

That the counterforts at the ſaliant angles ſhould be well braced or bound together.

When the ramparts are partly turfed and partly walled, he makes the intervals between the centers of the counterforts but 15 feet; but when they are walled quite up to the top, theſe diſtances are 18 feet.

Theſe dimenſions have been uſed in the conſtructions of a great many places, and the walls have never failed; it may however be demonſtrated that his low walls are too ſtrong, and the high ones too weak; but this ſubject ſhall be examined in the ſecond book, where practical fortification is treated of.

As M. *Vauban* has conſtructed the foregoing tables from practice and his own obſervations only, and not by the help of theory, without which it is impoſſible to arrive to any degree of perfection; the dimenſions contained therein are moſtly erroneous, which indeed appears by mere inſpection; for that all walls of any heights ſhould have the ſame thickneſs at top, is contrary to ſenſe and reaſon. Beſides, he makes no diſtinction

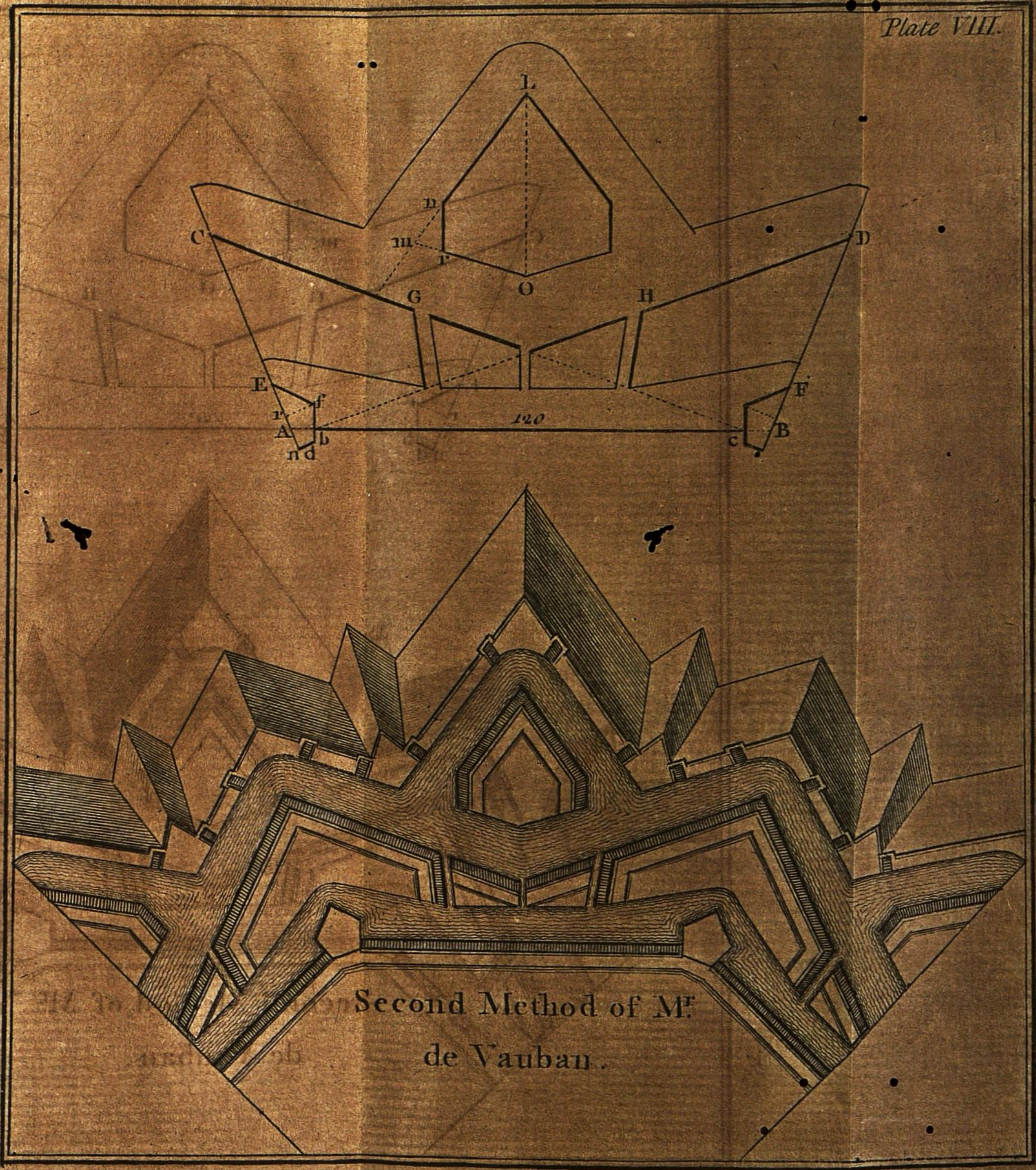
between ſtone and brick walls, although ſtones are ſpecifically heavier than bricks, and conſequently need not be made ſo ſtrong. For which reaſon we have inſerted tables for ſtone and brick walls in the ſecond volume of this work, which treats of the practice of fortification, deduced from theory and the moſt approved practice.

Conſtruction of M. Vauban's *ſecond method, with Tower-baſtions, according to the plans of* Landau *and* Beſſord.

This method is adapted to the fortifying of places built already; for which reaſon he begins his conſtruction inwards, and fortifies outwards, contrary to his other methods, as being more convenient for that purpoſe.

Plat. VIII. Let AB be the interior ſide of an exagon of 120 toiſes, ſome authors will have it 130, and ſay that they are ſo at *Landau*; draw AC, BD, from the center through the extremities of the ſides: ſet off 6 toiſes from A to b, and from B to c; through the points b and c, draw lines at right angles to AB; from the point b ſet off 6 toiſes to f outwards, and 4 from b to d inwards; and from the points

Plate VIII.



Second Method of Mr.
de Vauban.

points f, d, draw perpendiculars fr, dn, to the capital AC; then if r E is made equal to rf, the point E will be the ſaliant angle of the tower-baſtion; and Efdn half that tower.

If in the capitals, there be taken from the ſaliant angles of the tower-baſtions, the diſtances EC, FD, each of 40 toiſes, the points C and D will be the ſaliant angles of the counterguards before the towers: from the points C and D draw the lines of defence Cc, Db, to the points where the flanks of the towers cut the curtain; on which ſet off 56 toiſes for the faces of the counterguards, the flanks are found as in the firſt method, and likewiſe the tenailles.

The ditch before the ſaliant angles of the towers is 6 toiſes, and its counterſcarp drawn to the extremities of the flanks of the counterguards; the right line which joins the ends of theſe flanks will determine the inſide of the tenailles.

The ditch before the counterguards is 12 toiſes at the ſaliant angles, and the counterſcarp is drawn to the oppoſite ſhoulders in the ſame manner as in the firſt method.

The capital of the ravelin is 45 toiſes, its faces, when produced, terminate on thoſe of the counterguards, within 10 toiſes of the

ſhoulders; 10 toiſes are cut off from the faces by the flanks which are parallel to the capital as uſual.

The ditch before the ravelin is 10 toiſes, the covert-way 5, the ſemi-gorges of the places of arms 12, the faces 17, and the glacis 20.

Conſtruction of M. Vauban's *third method, according to the plan of* New-Briſach.

Plate IX. This method is applied to an octagon, whoſe exterior ſide AB is 180 toiſes, the perpendicular CD 30; the faces AK, BL of the counterguards 60: the flanks LN, KM are found by ſetting off 22 toiſes, as chords to the arcs deſcribed from the oppoſite ſhoulders as centers: from the extremities of the flanks a line is drawn, which will be parallel to the exterior ſide AB, meeting the capitals AE, BF, of the counterguards at G and H; this line terminates the inſide of the tenaille, as likewiſe the ſaliant angles G, H of the tower-baſtions.

If EF be drawn parallel to GH, and at 9 toiſes diſtant from it, the interſections E, F, with the capitals of the counterguards, will be

Third Method of Mr. de Vauban.

be the centers of the towers; from which set off 7 toises from E to *a* for the semi-gorges, and draw the flanks b c through the extremities of these semi-gorges perpendicular to the line EF; these flanks are 4 toises inwards from *a* to c, and 5 outwards from *a* to b; the faces b G are drawn from the point b to the point G, and the lines joining the inside of the flanks at the end of 4 toises will complete the towers.

The ditch is 6 toises before the saliant angle of the towers, and its counterscarp meets the line GH, within 10 toises of the extremities M, N of the flanks of the counterguards.

If from the point n, where the line EF intersects the perpendicular CD produced, you set off 5 toises to the point r, and the lines of defence are drawn from the extremities of the semi-gorges *a* of the towers through this point r; then the flanks of the counterguards produced will determine the little flanks p, q of the inside rampart, and the extremities of these little flanks being joined, will give the curtain between them.

The great ditch before the counterguards is 15 toises, and its counterscarp parallel to the faces: the capital of the ravelin is 55

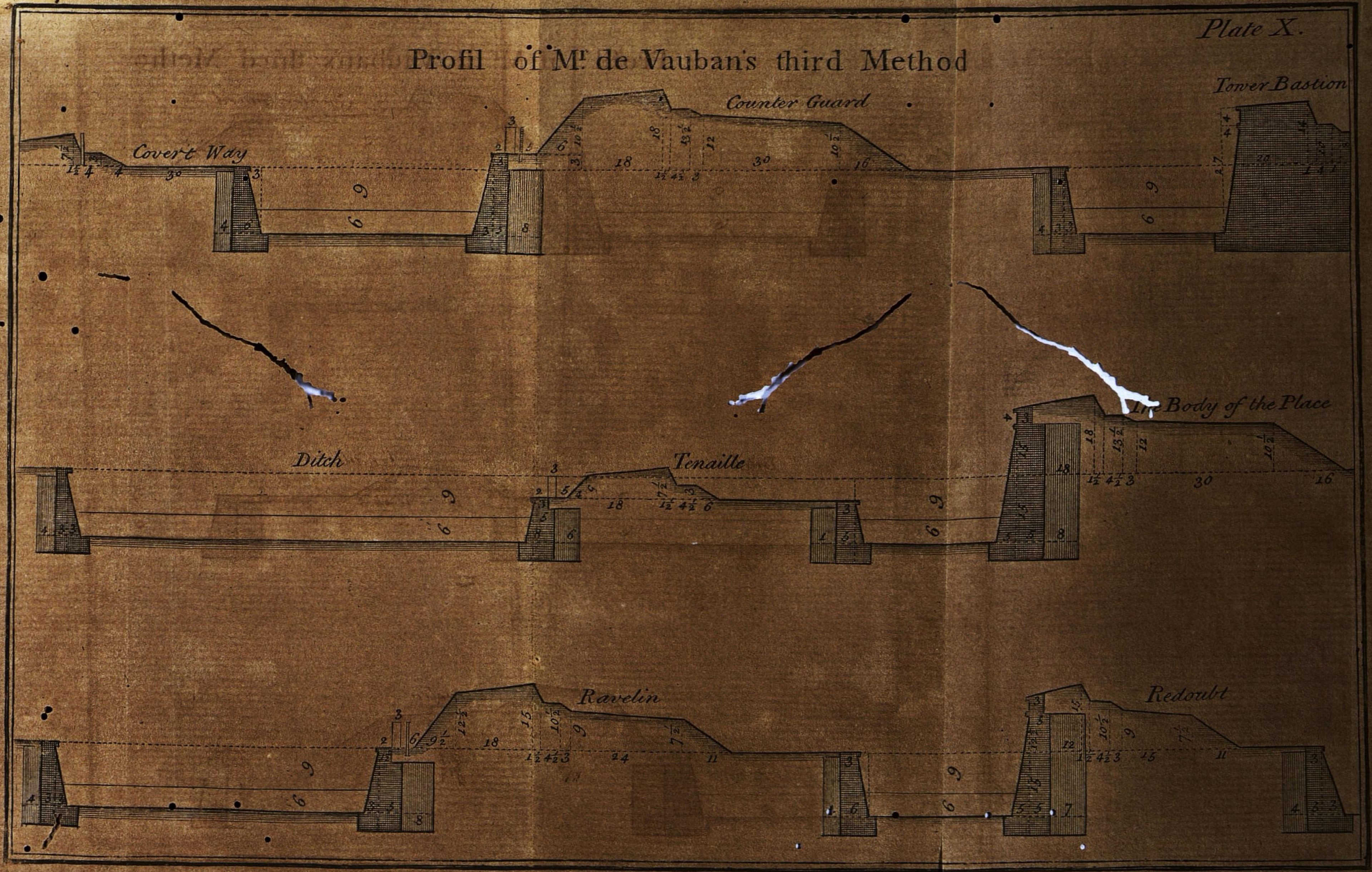
toises, and that of the redoubt within it 23; the faces of the ravelin are drawn to the faces of the counterguards within 15 toises from the shoulders, and those of the redoubt parallel to these: 12 toises are cut off from the faces of the ravelin, and 6 from those of the redoubt, by the flanks which are parallel to the capital; the ditch before the ravelin is 12 toises, and that before the redoubt 6: the covert-way and glacis are the same as in the second method: the profiles in plate X, XI, referred to this method, may serve likewise for the second. It must be observed, that the parapets of the counterguards, on both sides of the saliant angles, are raised 4 feet higher, for the space of 20 feet, above the rest, to prevent the enfilades of the ricochet batteries.

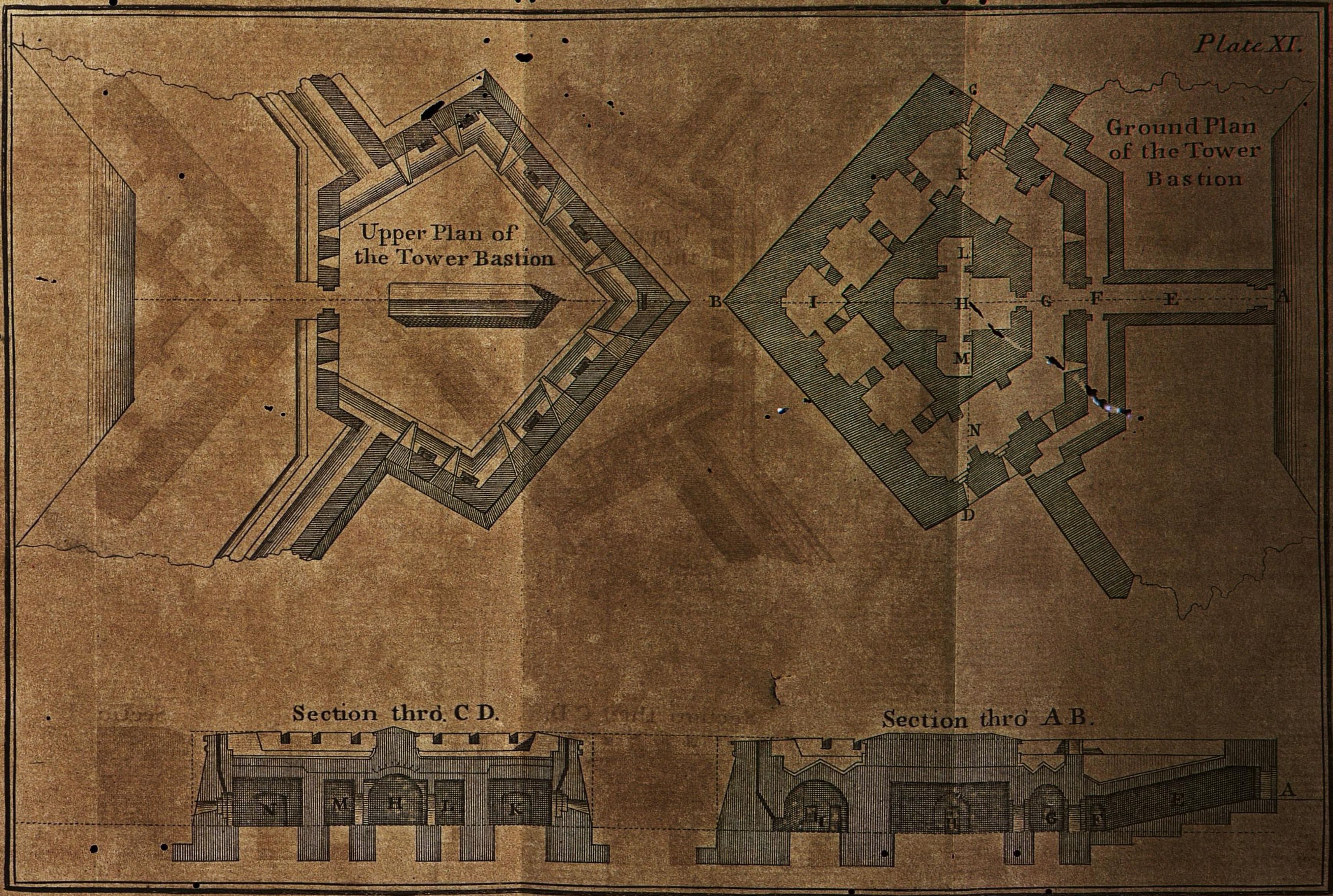
We shall examine these two last methods in the third section, in order to shew their perfections and imperfections.

Construction of M. Coehorn's *first method.*

Plate XII. This author applies his first method to an exagon, and supposes that the surface of the water is but 4 feet lower than the level-ground. Let

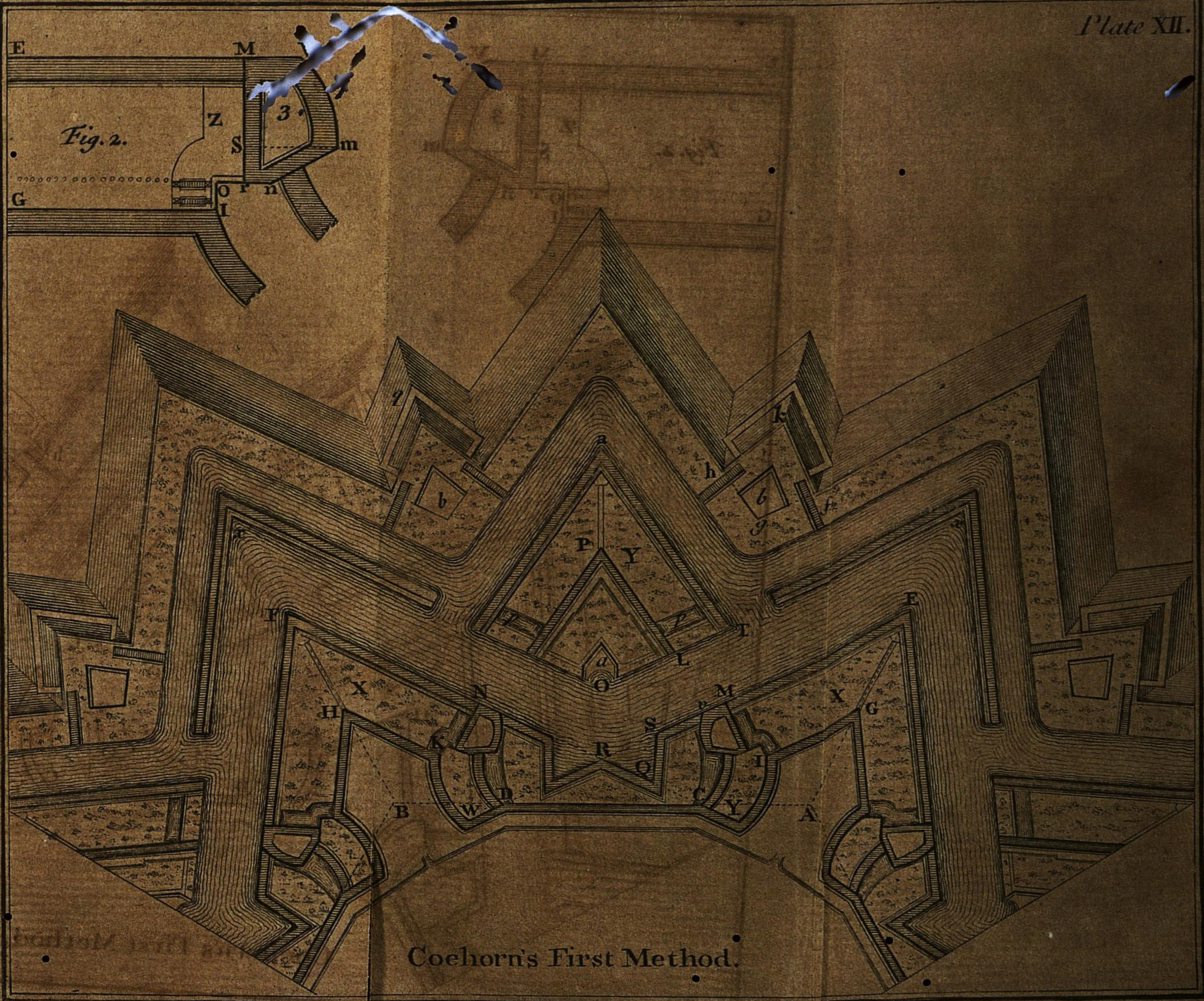
Plate X.


Profil of Mr. de Vauban's third Method
Covert Way
Counter Guard
Tower Bastion
Ditch
Tenaille
The Body of the Place
Ravelin
Redoubt



Müller delin. J.Mynde sc.

Plate XII.



Coehorn's First Method.

Müller delin. J. Mynde sc.

Let therefore the interior ſide AB of an exagon be 150 toiſes, take AC, BD, each equal to 39, and the capitals AE, BF, each of 80; and AG, BH, of 40; from the points E, F, draw the lines of defence through the points D, C; and through the points G, H, lines parallel to ED, FC; in which take GI, HK, each equal to 40 toiſes, for the length of the higher faces of the baſtions.

To determine the lower faces EM, FN, draw IO perpendicular to IG, equal to 4 toiſes; Or, parallel to IG, likewiſe equal to 4; then rM perpendicular to EM will determine the lower face EM. Fig. 1.

In order to determine the tower 3, ſee fig. 2; in rM, take rS of 5 toiſes, draw Sm parallel to EM, and equal to 14; in Or produced, take likewiſe rn equal to 4, and in EM, MV to 8; then if the points n, m are joined by a right line, and m, V by an arc of 60 degrees, you will have the outline of the tower.

The lines IO and Or, expreſs two walls, the firſt has two embraſures, and the ſecond three; by which the author intended to defend the dry ditch, and the approach to the tower.

If

If from the points C, D, fig. 1, there be set off on the lines of defence 14 toises to the points Y, W; and upon each of the bases YI, WK be described an equilateral triangle, the angles opposite to these bases, will be the centers of the higher flanks YI, WK.

And if R be the intersection of the two lines of defence, RM disected at S, and RC at Q; by drawing SQ, vSQR will be half the tenaille; and drawing from the point C, a line parallel to IY, so as to meet the tower, upon which the mean flank is described in the same manner as the former.

Fig. 2. The parapets of the three flanks, and those of the parts mV, VM, of the towers, are 24 feet thick; the other parts Mr, rnm, but 16; and all the other parapets in general are 20 feet.

There is a wet ditch before the mean flank of 6 toises broad, and another z, behind the towers of the same breadth, over which are made two draw-bridges, parallel to the higher faces.

The space X between the higher and lower faces of the bastions in a dry ditch, whose bottom is but 6 inches above the surface of the water in a wet ditch.

Behind

Behind the lower parapet there is a banquette of 3 feet, and a rampart of 5; and under this rampart a ſtone gallery, which runs from one end to the other, and is divided into ſeveral apartments, which are ſhut with doors; as likewiſe another, going from the ſaliant angle of the lower faces, to that of the higher, with loop-holes from diſtance to diſtance facing the dry ditch: there is likewiſe a row of paliſades placed parallel to the higher faces, and at 4 toiſes diſtant from them.

There are three embraſures in O r, as has been ſaid, to flank the ditch z behind the towers; and two in IO to flank the dry ditch near the higher faces.

The great ditch is 24 toiſes broad; and its counterſcarp parallel to the lower faces of the baſtions; the ſemi-gorges OL of the ravelin are 29 toiſes, and the faces LP, 45; the dry ditch Y is 16 toiſes, the rampart 28 feet, and the lower faces a T are parallel to the higher ones; the parapet of which is 20, and the banquette 3.

The level ground of the rampart in the ravelin near the ſaliant angle is 20 feet broad, for the length of 20 toiſes from that angle, and the reſt but 15.

In

In the gorge of the ravelin is a ſmall redoubt *a*, of about 5 feet high, and underneath a lodgment of ſtones, the walls being 18 inches thick at the ſides; the roof is made of planks, with 3 feet of earth over them.

There is a dry ditch going from the extremities of the faces to the redoubt, and round its angle, having a row of paliſades before it, to ſecure the retreat from the ravelin into this redoubt; there is likewiſe another row going from the extremities of the faces, in a round form, turning towards the gorge of the ravelin.

In the dry ditch of the ravelin, within 6 toiſes from the great ditch, is a coffer, and a ditch p of 6 toiſes before it: this coffer has a wall on both ſides, and the roof is planked and covered with a foot and half of earth; above this, is a ſtone parapet of 5 feet high, with a banquette behind it.

There runs a covered gallery under the rampart of the lower faces, and another joining the two ſaliant angles, together with a row of paliſades, in the ſame manner as in the dry ditch before the baſtions.

The wet ditch before the ravelin is 18 toiſes; the counterguards *x*, which the author calls *cover-faces*, are 25 feet broad, and the

the ditch before them 14 toiſes; the covert-way is 12 toiſes broad, and the glacis [illegible]: the ſemi-gorges fg, gh, of the places of arms, are 22 toiſes, and are taken from the point g, where the branches of the covert-way meet, and the faces fk, hk, are 28; within theſe places of arms are traverſes of 20 feet thick and 18 toiſes long, within 10 or 12 feet from, and parallel to the faces.

The ſtone lodgments b, within the places of arms, are found by ſetting off 12 toiſes from the point g, for the ſemi-gorges, and the faces are drawn parallel to thoſe of the places of arms.

At 6 toiſes from the places of arms, are coffers q of 8 feet broad, made with planks at the ſides, and above with a foot of earth over and before them.

There are two banquettes all round the covert-way, and before the traverſes; as alſo two rows of paliſades before the traverſes, one of which joins them, and the other goes round the covert-way.

Laſtly, the re-entering angles of the counterſcarp next to the covert-way are made a little round, as likewiſe that in the ravelin; but the contrary way, that is, they are made hollow.

Con-

Construction of M. Coehorn's *second method.*

Pl. XIII. The author supposes an eptagon, whose interior side is 126 toises, and the level of the ground to be 3 feet above the surface of the water.

Let, therefore, the interior side AB of an eptagon be 126 toises, take in the capitals, AC, BD, each of 72 toises; at the extremities C, D, make the angles ACE, BDF, each of 40 degrees; and set off 66 toises for the faces CE, DF of the bastions; on the interior side, take AG, BH, each of 30 toises, and from the point D, as center, describe an arc through the point G, on which set off a chord of 30; and on this chord describe the mean flank GI, which is an arc of 60 degrees.

Draw a line from the saliant angle D through the extremity I of this flank, on which take I a of 10 toises; join a E, on which describe the orillon as usual.

The outline of the higher flank is 13 toises distant from that of the outline of the mean; this flank is an arc described from the arme center as that of the former, the chord of which is 40 toises.

From

Plate XIII.

Coehorn's Second Method.

Müller delin.

J. Mynde sc.

From the points G, H, draw the broken parts of the curtain perpendicular to the capital of the baſtion, and make it 9 toiſes long; the extremity of the higher flank is terminated by the inſide line of the parapet of the curtain produced.

The tenaille is found, by producing the faces of the baſtions 10 toiſes; through the extremity of which, an arc is deſcribed from the oppoſite ſaliant angle of the baſtion, as center; on this arc is ſet off a chord of 20 toiſes; and this chord ſerves to deſcribe the flank, upon which is an arc of 60 degrees; the curtain is a right line.

There is a wet ditch before the tenailles of 10 toiſes broad, with two bridges at each end, near the orillons; the one directly over it, and the other along the faces of the baſtion.

The dry ditch round the body of the place is 20 toiſes broad, before the faces of the baſtion to which it is parallel, and the lower rampart KL, 29 feet; the ſemi-gorges ML are 15 toiſes, and the flanks LN, 18, and are deſcribed from the ſaliant angles K of the lower faces as centers.

The ſaliant angle of the ravelin is 125 toiſes diſtant from the curtain of the body

of the place, and is 70 degrees; the faces are 50 toises long; the faces of the redoubt x, are 16 toises distant from those of the ravelin, and 14 long.

The wet ditch round the lower faces of the ravelin is 24 toises broad: the work beyond this ditch, which the author calls the second counterscarp, is 20, parallel to the ditch.

To find the broken part of this work, join the two re-entering angles m, r; on which take m r, of 30 toises, and draw r t, r v parallel to the outline of the counterscarp, each equal to 12: set off 22 from t to s, and from v to q; and upon these lines as chords describe the round flanks, which are arcs of 60 degrees.

The traverses in this counterscarp are drawn at 10 toises from the flanks perpendicular to the parapet.

The redoubts z in the re-entring angles, are found by setting off 16 toises from the points m to n, for their capitals, and the faces are parallel to the broken curtain before them: those marked y, which are in the saliant angles, are found by producing the counterscarps of the great ditch, and setting off 12 toises from the points of their intersections for their faces; and

Plate XIV.

Müller delin. J. Mynde sc.

and the flanks are drawn parallel to their capitals.

The ditch before this work is 14 toiſes; as to the covert-way and glacis, they are the ſame as in the author's firſt method.

Conſtruction of M. Coehorn's *third method.*

The author ſuppoſes an octagon, whoſe interior ſide AB is 110 toiſes; the ſemi-gorges An, Bm, 21; the capitals AC, BD of the baſtions 64; and the ſaliant angles 85 degrees; the faces CE, DF of the baſtions 54 toiſes; the parts Qs, Qr of the tenaille 32; the lower flanks, that is, thoſe of the tenaille, are found by deſcribing arcs through the points s, r, from the oppoſite ſaliant angles DC, on which are 20 toiſes ſet off as chords; and theſe chords ſerve to deſcribe arcs of 60 degrees upon, for the required flanks. Pl. XIV.

From the extremities v, t, of theſe flanks, lines are drawn to the oppoſite angles D, C, and 6 toiſes ſet off from v to q; and upon qE the orillon is deſcribed as uſual.

The higher flanks are deſcribed from the ſame centers, as the lower through the ex-

tremities n, m of the curtain; and their chord is 30 toiſes.

The wet ditch before the body of the place is 20 toiſes, and its counterſcarp parallel to the faces of the baſtions.

The capital VW of the detached baſtion is 100 toiſes; the faces are directed to the ſaliant angles of the inner baſtions; the dry ditch behind the lower faces in the detached baſtions is 20 toiſes; and the higher faces are parallel to the lower, and 31 toiſes long: the towers x, and the ditch before them, are made in the ſame manner as in the firſt method. To find the flanks, make the ſemigorges Va, Vb, each 38 toiſes, and draw the chords of theſe flanks parallel to the capital VW; and from the extremities of the higher faces draw alſo lines to the former, upon which the flanks are deſcribed as uſual.

The counterſcarp of the ditch before the redoubt z, is drawn from the extremities of the flanks parallel to the faces; and at 6 toiſes from this, the faces of the redoubt are drawn; 4 toiſes of which are cut off for the flanks.

The ditch before the detached baſtion is 24 toiſes; the ravelins, counterguards, covert-

way,

way, and glacis, are the ſame here as in the firſt method.

There are little pits or points l, l, dug between the higher and lower curtains, to hold water, in order to prevent the paſſing from the tenailles to the flanks.

SECT. III.

Containing the general Maxims of Fortification, applied in the Remarks on the preceding Authors, and others mentioned hereafter.

IN learning fortification, with an intention to make any progreſs in it, it is not ſufficient to be capable of drawing lines, and to know the names of the different works; but it is neceſſary to be well acquainted with the principles or foundation on which the perfection and imperfection of a work depends; to be able to give reaſons for what is done, and to be in a condition to judge upon good grounds, what is good and what is not ſo, in the various manners of fortifying, by all the different authors who have wrote on this ſubject.

 There

There are three considerations essentially required in a good and well-ordered fortification, without any of which it can never answer the ends proposed.

The first is, the Expence necessary for the building of it: for should that be greater than the importance of the place requires, it is plain that such a place would be of no advantage.

The second is the Number of troops, to guard and to defend it: for if a place should require so many, as that the expence, together with providing it with artillery, ammunition, and stores, be equal to, or exceed the revenue or advantage arising from such a place, it is manifest, that instead of being an advantage, it would be a disadvantage.

And the third is, the Capacity of the town with regard to the space taken up by the fortification: for if it should happen that the town could not contain a sufficient number of troops to defend it, besides the inhabitants, it is evident that it may be taken with less expence than another of fewer works, provided with the same number of troops; and therefore, such a fortification will not answer the ends proposed in fortifying it: St. *Philip*'s Castle in *Minorca* is an instance of this

this ſort; and ſuch are M. *Coehorn*'s ſyſtems, as we ſhall ſhew hereafter.

If the queſtion was only to fortify a town ſtrongly, without any other conſiderations, one might make outworks upon outworks without end; but if it is conſidered, that a whole ſtate might be exhauſted in the building of one ſingle fortification, and which would require a whole army to defend it, it will eaſily appear, that the ſtrength and bigneſs of a fortified place ought abſolutely to depend on the importance it will prove to a nation.

Beſides the general conſiderations, there are ſeveral particular ones; which are neceſſary in the well-ordering all the different parts, ſo as to make the beſt defence that can be for a place of that expence.

1. There ought to be no part, but what can be ſeen or defended by ſome other; which in the phraſe of fortification is, all parts ſhould flank each other reciprocally; for flanking or defending is the ſame thing. For if there is any part that is not ſeen or defended, the enemy might approach that way under cover, and make themſelves maſters of it, without much trouble or loſs.

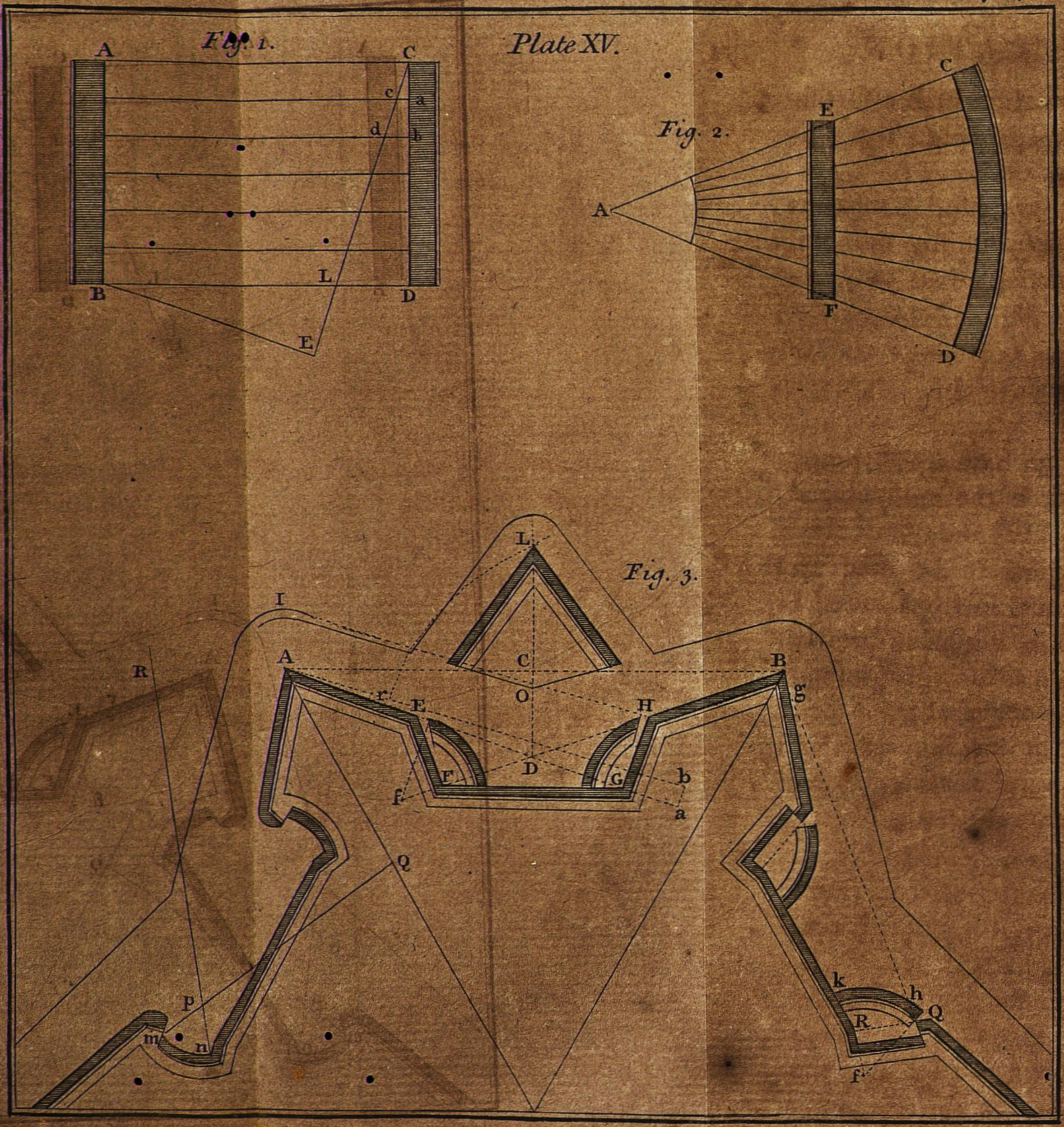
2. The defence of every part ſhould be always within the reach of muſket-ſhot, ſo as to be defended both by great and ſmall fire arms; for if it be only defended by cannon, the enemy may diſmount them by the ſuperiority of theirs, and then the defence would be deſtroyed at once; whereas, if a work is likewiſe defended by ſmall arms, then, if the one is deſtroyed, the other will ſtill ſubſiſt.

3. All the defences ſhould be as nearly direct as poſſible; for it has been found by experience, that the ſoldiers will fire directly before them, without troubling themſelves whether they do execution or not; there are other advantages in a direct defence, as we ſhall prove in the following propoſitions.

4. A fortification ſhould be equally ſtrong on all ſides, otherwiſe the enemy may attack it in the weakeſt part, whereby its ſtrength would become uſeleſs.

In a regular fortification, where all ſides are equally fortified, it cannot happen otherwiſe than to be every where equally ſtrong: but it is not ſo in the irregular, which requires great ſkill and knowledge to make a place ſo; and no author, that I know, has ſhewn how, and in what manner, we are to judge of the

ſtrength



Müller delin.

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ſtrength of the ſeveral parts in ſuch a fortification, although they all agree to the importance of that maxim.

There are commonly ſeveral other maxims given by authors, which, in my opinion, ought rather to be proved, than only aſſerted.

Proposition I.

Of two batteries which have equal fronts, that whoſe fire is direct is the moſt advantageous.

For let AB be an object to be fired at, from the battery CD equal in front; then I ſay, that this battery CD, which is directly oppoſite to AB, is more advantageous than any oblique one, as CL, whatſoever. Pl. XV.

For if CD be divided into any number of equal parts, ſuch as ca, ab, &c. and from theſe points perpendiculars are drawn to CD, interſecting CL, in c, d, &c. then, if each of theſe parts of CD is the ſpace neceſſary for one gun, or for one man; it is evident, that each of the correſponding parts Cc, cd, of CL, will likewiſe be neceſſary for one gun, or for one man: from whence it reſults, that there can be no more guns or men placed on the

 oblique

oblique battery CL, ſo as to fire at the object AB, than on the direct one CD.

Now becauſe the oblique battery CL is longer, and therefore of more expence than the direct one CD; and as the troops placed on the battery CL, fire with more uncertainty, eſpecially when they are in a hurry, and in danger, than if they were placed behind CD, where they only fire directly forward; it evidently follows, that the direct battery CD is more advantageous than any oblique one whatſoever.

N. B. As the parapets are 3 toiſes, or 18 feet thick, it is not only uncertain, that the ſoldiers in a hurry fire at an object obliquely ſituated, but likewiſe very difficult and troubleſome; ſo that beſides the advantage of a direct defence, mentioned in the laſt propoſition, this one is as much eſſential as any.

Proposition II.

If the object AB be a counter-battery, the direct battery CD is ſtill preferable to any oblique one CL whatſoever.

Let BE be perpendicular to CL produced; then the force, whereby a cannon-ſhot from

from the battery AB would ſtrike the battery CD, is to the force it would ſtrike the oblique battery CL, as BL to BE; or becauſe of the ſimiliar triangles BLE, CLD, as CL to CD; that is, reciprocally as the lengths of the batteries.

But the reſiſtances of the batteries are reciprocally as the forces whereby they are ſtruck, and therefore directly as the lengths or expences.

But the reſiſtances of theſe batteries are only at the beginning, as the expences; for as ſoon as the leaſt breach is made in the wall, they nearly equal: beſides, if the guns of the battery AB fire directly, as they eaſily may, except the battery CL is very oblique, the reſiſtances will be equal from the beginning; and as the guns are as eaſily diſmounted on the oblique battery CL, as on the direct one CD, it evidently follows, that the direct battery CD is more advantageous than the oblique one CL.

Corollary.

From whence it follows, 1°. that if the fire from the battery CD is to be directed towards a point A, the battery CD ought to be Fig. 2.

be an arc of a circle, described from that point A, as center.

2°. And if the fire from the battery CD is to be directed to a line EF, of a greater or lesser extent than the battery, it ought again to be an arc of a circle, such that the radii CA, DA, drawn from its extremities, shall pass through the extremities E, F of the object, and make equal angles therewith.

PROBLEM.

To determine the several parts of a front of a fortification,

Fig. 3. I. It is evident, that every part of the front AEFGHB, disposed in the manner described before, is seen and defended by some other part, as well as the ditch before it: for the flank HG, defends the ditch from the perpendicular CD to the face EA produced, as well as that face itself; the flank EF and half the curtain, and the flank EF defends the other half of the ditch from CD to the face HB produced, that face the flank HG and half the curtain; and consequently no part of this front can be approached, without being seen and defended by some other part.

II.

II. The next thing to be confidered, is the length of the lines of defence AG, FB, which fome will have to be within mufket-fhot, and others longer; the firft fay, that the principal ftrength of a fortification confifts in the ufe of fmall arms, becaufe the guns fire but flowly, are foon difmounted, and require much time to be remounted; whereas the fire from fmall arms is very brifk, and when one man is killed, another takes his place immediately; this is anfwered, that cannon does greater execution, and requires much trouble to make an epaulement to refift their force, whereas a moderate epaulement is a fufficient cover againft fmall arms: befides, when the lines of defence are of a fufficient length, the feveral parts of the fortification become fpacious and more convenient for placing both more guns and men in them; it alfo obliges the enemy to extend their trenches much farther, than if thefe lines were fhorter.

But it is evident that, although the lines of defence are within mufket-fhot, there may be placed both fo many men and cannon as are neceffary to defend the works; and the works are likewife fpacious enough for all other purpofes.

From

From whence it is concluded, that the length of the lines of defence ſhould not exceed the reach of muſket-ſhot, which is commonly obſerved now-a-days; except when the front lies near a great river, and can hardly be attacked on that ſide, there they are often made longer.

It has been found by experience that a common muſket-ſhot will hardly kill a man at a greater diſtance than 160 fathoms Engliſh meaſure; and therefore the lines of defence ought not to exceed that length when the front can be approached.

III. The length of the faces AE, BH ſhould be ſuch, that the flanks are of a ſufficient length, and the gorges of the baſtions not too narrow: they are never made leſs than 50 toiſes, nor greater than 70, in a fortification whoſe exterior ſide is 180 toiſes or upwards.

But as to the length of the perpendicular CD, it is no ways determined; for ſome engineers make it twice as long as others: they ſeem indeed to differ from one another, merely out of contradiction; ſince none of them, that I know of, has given any reaſons for this practice; although it be plain, that the longer this perpendicular is, the greater the

the flanks will be, therefore the defence ſo much the greater likewiſe.

But then the expences increaſe alſo in proportion, and conſequently the length of the perpendicular ſhould be determined according to the expence which a ſtate will be at, and according to the importance of the place.

IV. The poſition of the flanks is no more certain than the reſt, ſince almoſt all engineers differ from one another in that reſpect: although it is evident that there muſt be a certain and determinate poſition better than any other.

For if their uſe be conſidered, the poſition will eaſily be known, as they are to defend the ditch before them: and it is a received maxim in fortification, that the direct defence is the beſt; and we have proved in the two foregoing propoſitions, that it has ſeveral advantages above an oblique: one it follows from the corollary after theſe propoſitions, that the flanks ſhould be an arc of a circle deſcribed from the point of interſection, of the line of defence and oppoſite counterſcarp produced, as center: or, becauſe this arc differs but little from its chord, a right line which makes equal angles with the

line of defence, and the counterſcarp produced.

Having thus determined the ſeveral parts of a front, we ſhall proceed in our examination of the ſeveral parts of the two foregoing authors fortifications.

Remarks on M. Vauban's *firſt method.*

This method is very ſimple, eaſily conſtructed, takes up but little ground, ſince the inward ſpace left for buildings is to the ſpace taken up by the fortification, comprehending ravelins and covert-way, as 970 to 1622 nearly; that is, the fortification takes up about one and a half more ground than the buildings: it is free from all ſurprizes, by its ſtone revetements, requires not many men to defend it, by the contiguity of its works, and is of very good defence, eſpecially when ſome outworks are added; ſuch as counterguards before the baſtions, lunettes, or tenaillons, to cover and defend the ravelins.

But it muſt be confeſſed that his flanks are too ſmall, ſince the enemy can always erect counter-batteries ſuperior to them; as M. *Coehorn* obſerves (pag. 11. Engliſh edit.); but with

with regard to the battery, which he pretends to place in the ravelin, it is only a conceit, to impoſe upon the incautious reader; ſince the fire from the whole curtain can always deſtroy that battery, as being much ſuperior to it, and which cannot be ſilenced till the ravelin is taken and a battery erected in it.

The poſition of his flanks come pretty near to the true one, ſince the difference between the angles made by the flank, and the lines of defence, and counterſcarp produced, is but about 2 degrees, which is inconſiderable in practice.

The manner of making retired flanks covered with orillons, is very good; becauſe the flanks cannot be diſcovered by any oblique batteries, and there may be a gun placed behind the orillon, which can be ſeen from no where elſe than from the breach in the oppoſite face of the baſtion.

But for what reaſon he makes his retired flanks to be a circular arc of 60 degrees, is inconceivable to me; ſince flanks are made for no other purpoſes, that I can find, than to defend the oppoſite ditch; they ought evidently to be ſuch arcs as we have demonſtrated in the preceding problem, or right lines, which make equal angles with the line

line of defence and counterſcarp produced. But inſtead of defending the ditch directly, they defend all the part of the fortification contained within the angle QpR, made by the radii n p, m p produced; ſo that it ſeems as if theſe flanks were made quite for other purpoſes than to defend the ditch; and what is more ſurpriſing ſtill, all modern engineers follow him, as if it were the beſt defence that could have been invented; which plainly ſhews, when men go upon uncertain principles, how eaſily they are led into errror. It is true, they imagine to get more room by making this ſort of flanks, and that they reſiſt better the fire of the enemy.

But theſe pretended advantages are founded upon as erroneous principles as the reſt; for we have proved, that the flank made upon its chord will contain as many guns as that made on the arc itſelf, and reſiſts better than the curved flank; as is eaſily demonſtrated by mechanics.

His capital ditch is too wide; for if it were but about 16 toiſes at the ſaliant angles of the baſtions, and from thence drawn to the inner angles of the parapets at the ſhoulders, the flanks would then not be ſo much expoſed as they are now, and there would be

be less room on the glacis to erect counter-batteries.

We have shewn the general usefulness of tenailles, after their construction; as likewise their perfections and imperfections.

As the ravelins are chiefly made to cover the flanks and curtain, M. *Vauban* ought not to terminate their faces on the shoulders of the bastions, but rather 3 or 4 toises beyond them: those of the second sort are still worse, because their flanks lay the flanks of the bastions still more open than the first: the third sort, which have redoubts within them are the best; for they secure a retreat to the troops in the ravelin, and the enemy is obliged to raise a battery in the ravelin to destroy the redoubt; it takes likewise a good deal of ground from the besiegers, who cannot therefore erect such large batteries in them, against the curtain or flanks.

The lunettes are of a very good defence, especially when there is a bonnet to cover the saliant angle of the ravelin, as we have mentioned in their construction: the same thing may be said in regard to the tenaillons.

Instead of making the semi-gorges of the bonnet 15 toises, I would make them but 8 or 10 at most, whereby the defence of

its ditch and covert-way would be greater, and the besiegers would find less room in them for batteries.

The faces of the lunettes should be one perpendicular to the face of the ravelin, and the other to that of the bastion, in order to be defended in a direct manner, which ought to be observed in all works, if possible.

Some authors object against the lunettes, on account that the ditch, which is defended by the ravelin, has no defence left as soon the ravelin is taken; but as it is hardly possible to take the ravelin without being first master of the lunettes, their objection is of no consequence; and should the besiegers be imprudent enough to pass by the lunettes without taking them, they must certainly suffer much more than if they had.

The counterguards before the ravelins are but seldom made; for a redoubt within the ravelin answers the same purpose, and is less expensive: but as to those before the bastions, they are some of the best of all outworks, when they are well constructed; since the enemy cannot pretend to make a breach in the bastion, nor destroy the flanks before they are masters of the counterguard; and then they have not sufficient ground to

make

make batteries in them, to deſtroy the flanks and make a breach.

All tenaillons and counterguards ſhould have retrenchments, ſuch as that marked by the letter K, fig. 6. in the ſecond plate: for by this means their defence becomes much more conſiderable than without them. This the *French* have done in their counterguards lately conſtructed before the baſtions at *Lille*, and in the tenaillons at the front which was attacked by Prince *Eugene* and the Duke of *Marlborough* in Queen *Anne*'s war; when theſe tenaillons made one of the beſt defences that ever was known.

M. *Blondel*, and after him M. *Coehorn*, make their ramparts ſo narrow, as to leave no room to place guns upon them; and this is to prevent the beſiegers from erecting batteries there, whereby they will be obliged to bring earth from the covert-way, in order to deſtroy the flanks. But as theſe counterguards are only defended in the front by ſmall arms, they can make no great reſiſtance; beſides, the beſiegers may make a few mines under them, and ſo blow up as much as will diſcover the faces and flanks from the covert-way; whereas, if their ramparts are 7 or 8 toiſes broad, they cannot be deſtroyed

 by

by mines; and there will neverthelefs not be fufficient room to erect batteries in them to deftroy the flanks.

I would chufe to make thefe counterguards as high as the baftions themfelves, in order that the enemy might not difcover the baftions but from within the counterguards; by which means the fire of the whole baftion would defend the counterguards in fuch a manner, as to make it almoft impoffible to make any lodgment there.

The horn and crown works are chiefly made, to take away a fpot of ground which might be advantageous to the enemy; to cover the gates of the town, or to build ftorehoufes and hofpitals in them.

The flanks are too fmall, as well as the fronts themfelves, and the ditches before the branches are too obliquely defended: the retrenchments made in them are very good, to retire behind when the work is taken, and to difturb the lodgments made there.

Thefe kind of works ought never to be made, but upon the above-mentioned occafions; for their building is very expenfive, and cheaper works would be of a much better defence; notwithftanding M. *Vauban* has too profufely made them, in the fortifica-

tions of *Tournay*, *Ipres*, and in ſeveral other places; and placed them often ſo near each other, as would incline one to believe, that he rather intended more to terrify an enemy by their number, than to ſtrengthen the place.

The covert-way ſeems to be of a ſufficient breadth to contain the neceſſary troops to defend them, and the traverſes are abſolutely neceſſary for their defence; contrary to the opinions of M. *Coehorn* and others; for without them the covert-way may be enfiladed by the ricochet batteries, from one end to the other: beſides, when the ſaliant angle is attacked, the beſieged have a ſecure retreat behind them; and ſo may be defended to the laſt extremity; experience has ſufficiently proved their uſefulneſs, for at *Liſle* a traverſe was three times taken and retaken.

M. *Vauban* invented three different manners of covering the paſſages round the traverſes at the ſaliant angles; the one by cutting the paſſes out of the glacis, as in plates VIII and IX, the other by making a kind of ſhoulder before them, and the third in the form of the teeth of a ſaw, which he calls *en Cremaille*, ſo as the paſſage may be ſeen

 and

and defended from behind the traverſe which forms the place of arms at the re-entering angle; which is undoubtedly preferable to the other two, and has been practiſed in all the fortifications built in latter times.

I am not ignorant that the whole front of the covert-way is ſometimes attacked at once; in ſuch a caſe, the traverſes ſeem to be uſeleſs; but as this only happens when the garriſon is very weak, or the enemy preſumptuous and unſkilful, they generally pay dear for their raſhneſs, and ſeldom can maintain their ground. Beſides, the beſiegers may drive the troops out of the covert-way with their ricochet batteries, when they are as yet far off, ſo that it is of no manner of uſe after the ſecond or third day of the attack; but to prevent the traverſes being uſeful to the beſiegers in covering them, I would chuſe to make a ſmall mine under them, and when they can no longer be defended, to blow them up.

The arrows and detached redoubts are of no great expence; and nevertheleſs are very good in hindering the enemy from beginning their trenches too near, and to diſturb them in their approaches; but the redoubts are liable to be ſurrounded by the trenches and

taken by the gorge, if they are not well protected from the covert-way or ſome other outwork; for which reaſon they ſhould never be farther from the covert-way than about 50 toiſes; and if they were mined ſo as to be blown up when they can be no longer defended, they would afford no ſhelter to the enemy when they are taken.

As to the ſecond ditch and covert-way, they being works only made of earth, are of no great expence, and yet may make a very good defence, eſpecially when the ſlope of the firſt glacis goes as low as the ſurface of the water; or when the water can be raiſed in time of a ſiege, ſo as to overflow the beſt part of the firſt glacis; it would oblige the enemies to bring earth from the ſecond glacis to retrench themſelves upon the firſt, which would coſt them a good deal of time and trouble; and as this muſt be done under the grazing fire of the covert-way, it could not be done without much coſt and danger: the ſecond covert-way ſhould be not above a foot above the ſurface of the water in the ditch, to oblige the enemy to bring earth for making their trenches in it.

M. *Vauban* was ſo ſenſible of the goodneſs of theſe works, that he never failed to make

them where-ever he found the ground convenient for it; as may be ſeen at *Sarre Louis*, at the city of *Liſle*, and in other places.

Remarks on M. VAUBAN's *ſecond and third methods.*

The deſign of the ſecond method is to fortify an old town already incloſed by a rampart; and it is for that reaſon that he begins within and fortifies outwards, contrary to his other methods, as being more convenient in this caſe: the tower-baſtions are joined to the old wall, and have underneath a magazine in the form of a croſs; all round this magazine are caſemats, or cellars, to hold both men and guns; thoſe in the flanks have each an embraſure which opens into the ditch, and thoſe in the faces have embraſures ſo as to fire out of one into the other when taken by the enemy; and above is a parapet of 12 feet thick with embraſures, as may be ſeen in plate XI, where a plan and ſection of a tower-baſtion is repreſented.

As theſe towers are almoſt a ſolid bulk of maſonry, they muſt be of great expence, though their reſiſtance can be but little; for it has been found by experience, that the caſe-

mats

mates are but of little uſe, becauſe, as ſoon as they have fired once or twice, the ſmoak will oblige the defenders to leave them, notwithſtanding their ſmoak-holes.

In my opinion, inſtead of attacking the towers themſelves, the ramparts near the flanks of the counterguards may be attacked; and then the flanks of the towers may be deſtroyed by the guns placed on the flanks oppoſite to them, which are already made for that purpoſe, and want nothing elſe but embraſures.

It may be concluded, that the ſtrength of theſe towers does by no means anſwer their expences; and that if ſmall baſtions were made inſtead of them, without caſemats, they would be much better, and of leſs expence.

As to the counterguards, they are very good, and may be defended to the utmoſt extremity, without expoſing the town to be taken by ſtorm; but their flanks are too ſmall, and are eaſily deſtroyed from the oppoſite covert-way; there ſhould either be two, or if but one, it ſhould be pretty large.

M. *Vauban* conſidering, that as ſoon as a breach was made in the faces of the baſtions, and the paſſage over the ditch finiſhed, the garriſon

garrison is always obliged to capitulate, whereby the little defence they make by no means answers the great expence in constructing them, rightly judged, that if they were detached, it would be much better; for by this means they may be defended inch by inch to the very last, without exposing the town.

For these reasons M. *Vauban* invented his third method; but as it differs only from the former in having two small flanks in each curtain of about 4 toises, which can hardly hold two guns each, and therefore add no great strength, the same exception which we made against the second method, may be made likewise against this.

M. *Vauban* has been censured for making flanks to his ravelins in these two last methods; because the flanks of the counterguards are said to be obliquely seen thereby, from the covert-way before the ravelin. But as they can be seen only under a very small angle, they cannot receive any damage from thence; and these flanks defend the saliant angle of the counterguards extremely well; this objection has not the least foundation. I may venture to say that all the works of the second and third method are as properly made and

and may make as good a defence as could be wiſhed; the tower-baſtions and the ſmall flanks in the third excepted.

Remarks on M. Coehorn's *firſt method.*

Before we enter into any particulars of this method, it is neceſſary the reader ſhould know, that M. *Coehorn* wrote his book before he had acquired that great experience, for which he has been ſo juſtly eſteemed one of the greateſt engineers that ever was, in order that they may not be miſled by the exceſſive praiſes beſtowed by ſome authors, on account of his works which are publiſhed, although impracticable in themſelves, and undoubtedly thought ſo by M. *Coehorn* himſelf, after he was a better judge of fortification, as evidently appears by the towns he fortified afterwards; for if he had thought that his works could really make that prodigious defence, which he pretends in his writings, it would be very ſtrange, that he ſhould not have made uſe of them, when he had an opportunity to do it.

Having thus ſhewn in general, that the author himſelf diſapproved his works; we

 ſhall

ſhall now proceed to ſhew the advantages and diſadvantages of the particular parts.

We ſhall begin with ſhewing that the expence which he pretends to be much leſs in the building of this fortification, than that of the *French* method, is not ſo inconſiderable as he fain would perſuade the world: firſt the room within for buildings, is to that taken up by the fortification, as one to three nearly, rather more than leſs; and as he makes his inward polygon equal to that of M. *Vauban*'s exagon; and we have found, that the inward polygon is to the ſpace taken up by the fortification, as unity to 1 $\frac{1}{2}$; the fortification of M. *Coehorn*'s method takes up juſt as much ground again as that of M. *Vauban*, and therefore double the expence for removing the earth; but then he ſays, that much leſs maſonry is required here than there, and it is upon this he grounds his frugality; but it has been found by experience, that works of earth coſt as much in time, as thoſe made of ſtone, on account of their continual repairing; ſo that in the whole it appears, that M. *Coehorn*'s exagon coſts more, or at leaſt as much as M. *Vauban*'s exagon; then if we conſider the lowneſs of theſe works, and how eaſily they may be ſurpriſed, they will

will require at leaſt three times the number of troops and ammunition to defend them, as the *French* one.

For when a place is out of danger from being ſurpriſed, there requires but a few troops to guard the works which are not attacked; whereas, on the contrary, the others muſt be every where equally guarded; otherwiſe the beſiegers may make a ſham attack on one ſide to draw the beſieged that way, and ſurpriſe ſome of the works on ſome other ſide.

The next thing is to examine whether the different works are conſtructed in the beſt manner: firſt, as to the upper and mean flanks, they ſeem to be the only thing the author borrowed from the *French*, and is juſt the worſt of all M. *Vauban*'s works, as we have ſhewn heretofore: the curtain of the tenaille would have been better ſtraight than crooked; the towers being but ſmall, and a parapet quite round them, are very dangerous, and a fair mark for throwing ſhells, by which there is no ſecurity for thoſe within: the dry ditches and lower faces of the baſtions and ravelin are eaſily enfiladed by the ricochet batteries; and the paliſades placed in them, to ſecure a ſafe retreat, are very dangerous; becauſe if a ſhot hits them, the ſplinters will do more miſ-

miſchief than the ſhot itſelf, as to the caſe-mats in the towers, they are very bad, as we have ſhewn before, ſpeaking of the tower-baſtions; the ſtone galleries made under the ramparts of the lower faces of the baſtions and ravelins, ſeem to be uſeleſs, on account of the ſmoak, for the ſame reaſon as all caſe-mats are; and if ſome grenadiers go between the loop-holes and fling a few grenades into them, they muſt infallibly deſtroy thoſe within.

The redoubt in the gorge of the ravelin is of excellent uſe to ſecure a ſafe retreat to the beſieged, which is in my opinion of the greateſt conſequence; for if the troops have no retreat, they can never defend a work ſo well as they might do otherwiſe.

The wet ditch before the lodgment and the dry ditch of the ravelin, are in a wrong place, ſince they are directly oppoſite to the ditch before the counterguards; and theſe lodgments themſelves being only a ſtone wall, are eaſily deſtroyed by the ricochet batteries.

The rampart of the counterguards being only 28 feet broad, including the parapet, they are eaſily deſtroyed by mines, as we have mentioned before, ſpeaking of counter-guards; no cannon can be placed in them: neither are their ditches defended by cannon,

except

except from the higher faces of the ravelin; and as to the covert-way, it is by much too ſpacious, and liable to be enfiladed from the beginning of the ſiege, by the ricochet batteries placed before the firſt parallel; ſo that of this ſpacious work, there are only the places of arms which can make a defence; the redoubts in the places of arms being incloſed quite round, are dangerous to defend, for a few ſhells thrown into them muſt inevitably deſtroy thoſe within, or oblige them to quit the work; and they are contrary to the general maxim of fortification, that no part whatſoever ſhould be ſo as not to be ſeen or flanked by ſome other; but here, if the enemy gets once poſſeſſion of theſe redoubts, the walls near the counterſcarp will cover them in ſuch a manner, as not to be ſeen from any part of the fortification.

As to the coffers made in the glacis, they cannot much retard the approaches of the enemy, being only defended by ſmall arms; ſo that a few gabions filled with earth will eaſily cover the beſiegers againſt the fire of theſe works.

It is moſt certain, that when M. *Coehorn* publiſhed his book, he knew nothing of the ricochet firing, the invention of which being of

of later date; and therefore was not aware of the inconveniencies which attend now-a-days these low works; otherwise he would never have made use of them; and it is undoubtedly for this reason, that he never put them in practice afterwards, when he was acquainted with this manner of firing; the manner of fortifying *Bergen-op-zoom* differs so little from M. *Vauban's* first method with orillons, that I took it for the very same till I was better informed; and this place is undoubtedly a master-piece of art.

The comparing of this method with the *French* exagon, fortified with ravelin and covert-way only, is not just; for the one takes up twice as much ground, and requires about three times more troops to defend it than the other, and therefore there ought to be no more comparison between them, than there is between a place of few works, and another of a great many; but to make the comparison just, the author should have compared his exagon with a *French* one of an equal number of works.

M. *Coehorn's* second and third methods are absolutely impracticable; for their fortification takes up five times as much ground as the town; and therefore the town would hardly

hardly hold more people, than the number of troops required to defend the fortification, besides the store-houses for the prodigious number of artillery and stores.

As we have shewn the faults M. *Coehorn* has committed in his works, which he has published before he acquired that great knowledge for which he is so justly esteemed as one of the greatest engineers, justice requires that we should likewise mention his extraordinary skill shewn in fortifying *Bergen-op-zoom*; which is one of the best contrived fortifications in all Europe.

Having thus finished our examination of the methods of two most celebrated authors, we shall now proceed to shew in what manner the several parts of the body of the place are to be constructed, so as to be capable of the best defence, proportionably to the expence.

A new Construction.

Let AB be the exterior side of any length, suppose 180 toises; make the perpendicular CD of any length, as the 6th, 5th, or 4th part of the exterior side, according to the expence or importance of the place: here Plate XV. Fig. 3.

it is the 6th part or 30 toiſes, ſet off 50 toiſes or more for the faces BH, AE, or rather $\frac{2}{7}$ of the exterior ſide; from the ſaliant angle A deſcribe an arc with the radius AI of 20 toiſes, that is, 2 or 3 toiſes more than the breadth of the ditch; draw from the oppoſite ſhoulder H a tangent HI to that arc, and from the angle A the indefinite line Ab parallel to that tangent; then if from the angle A, as center, an arc a b be deſcribed with any radius, the flank GH is drawn parallel to the chord a b: one of the flanks being thus found, the others will be found by taking the diſtance DG, between the perpendicular and the angle of the flank, and carrying it from the extremities of all the perpendiculars on the lines of defence, as from D to F; this being done, the counterſcarp of the ditch is drawn parallel to the line HI or to Ab; and having the point or re-entring angle O, its diſtance from the extremity of the perpendicular, being carried all round, will give the re-entring angles before the other fronts.

The tenailles h k, which M. *Bellidor* has invented, and called them *Rams-horns*, are deſcribed, by ſetting off 3 toiſes from the ſhoulder Q of the baſtion to the point h, and drawing

drawing h f perpendicular to the line of defence; then its interſection f, with the other line of defence produced, will be the center of the arc h k.

To conſtruct the Ravelin.

Set off 12 or 15 toiſes from the ſhoulder E to the point r, in the face of the baſtion, and from the angle G of the flank, as center, deſcribe an arc through the point r, meeting the perpendicular CD produced at L; from this point L draw the faces, ſo as when produced to fall on the faces of the baſtions within 3 toiſes of the ſhoulders; the ditch of the ravelin is 12 toiſes.

To conſtruct Retired Flanks.

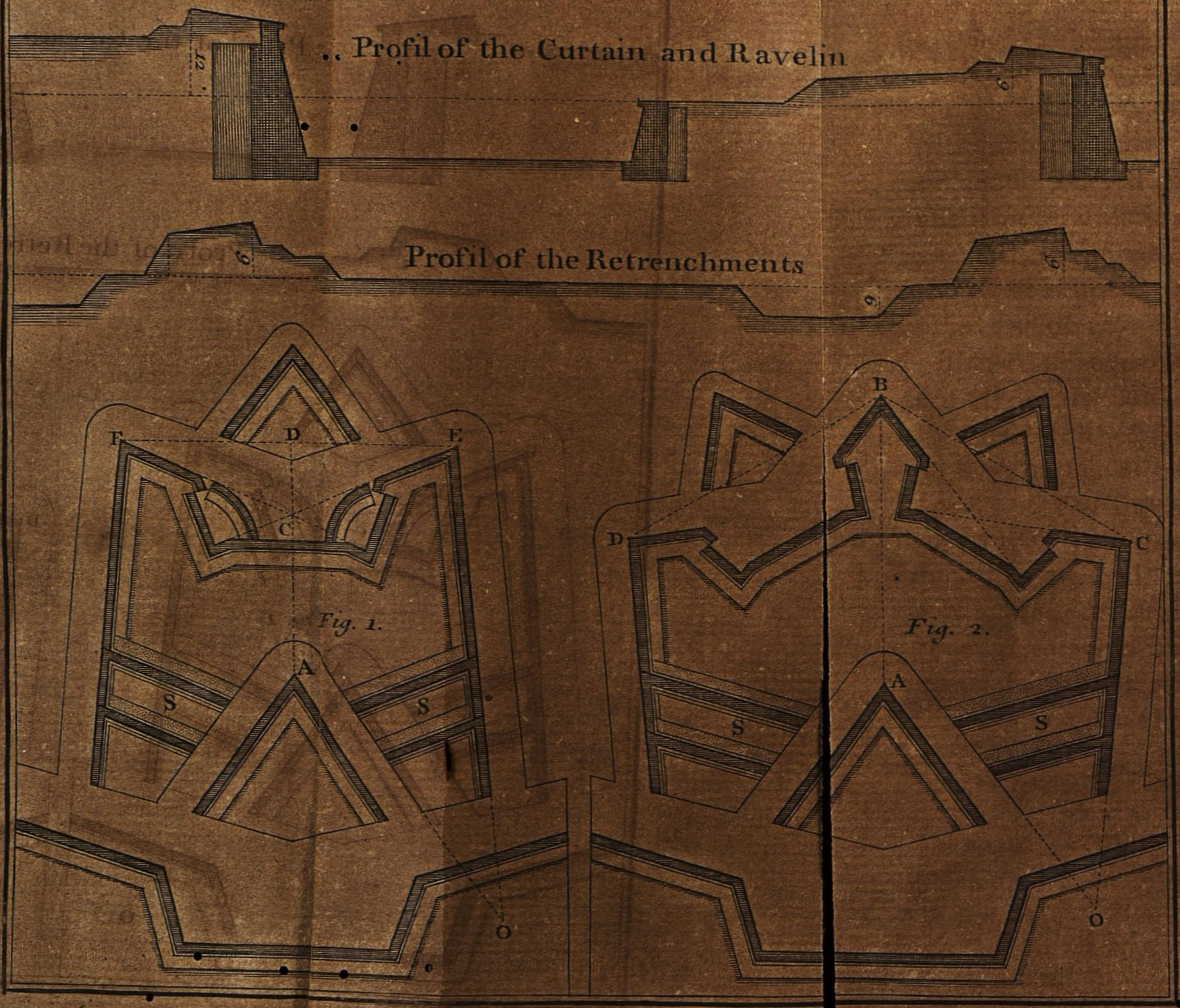
Find the flank QR as before, on which ſet off 5 or 6 toiſes for the ſhoulder or orillons; and from a point g in the oppoſite face of the baſtion at 5 toiſes from the ſaliant angle B, draw the broken part of the flank; then draw the retired flank parallel to the line Q R, at 5 toiſes diſtant from it: the orillon may be made round in the manner of M. *Vauban*'s, if it be thought proper.

Remarks on this construction.

This construction is general, let the exterior side AB be what it will; the flanks make equal angles with the lines of defence and the counterscarp produced, and therefore defend the ditch in the most direct manner; the counterscarp terminates at the inner angle of the shoulder, so that the gun placed in that angle grazes all along the counterscarp: the ravelin is of a due proportion, its saliant angle is neither too narrow nor too open, and its faces cover the flank of the bastions sufficiently from being seen obliquely.

The orillons are made 5 toises long only, which appears to me sufficient for covering the retired flanks, and by making them so, the flanks are larger than if they were made 9 toises, as M. *Vauban*'s: the rams-horns have several advantages over the common tenailles; they cannot be enfiladed, leave more room between them and the flanks, so that the rubbish from the flanks do not incommode the troops in the rams-horns; and being circular, they see not only the ditch directly, but likewise the level ground of the ravelins, and the opposite covert-way; they also resist the opposite batteries

Plate XVI.


Profil of the Curtain and Ravelin
12
9
Profil of the Retrenchments
9
9
9
F
D
E
C
Fig. 1.
A
S
S
O
B
D
C
Fig. 2.
A
S
S
O

teries much better, and are of leſs expence in their conſtruction, and therefore preferable in all reſpects to the common tenailles.

If theſe flanks are not thought ſufficient, another might be made behind them, in any polygon above an exagon, without making the gorges of the baſtions too narrow; there might even be made another in an exagon, provided the firſt be only 20 feet retired, and this would be ſufficient to cover it.

By drawing the line which terminates the retired flank from a point g within five, or rather ten toiſes from the ſaliant angle B of the oppoſite baſtion, a gun may be placed at the extremity of that flank, which ſees into the breach made in the face AE, and which cannot be ſeen from any part of the oppoſite covert-way, and therefore cannot be diſmounted but by mortars, which is not ſo eaſily done.

To conſtruct Horn and Crown-works.

When there is a neceſſity to conſtruct horn or crown-works, either to cover a gate, or to occupy a ſpot of ground which might be advantageous to the beſiegers, and which can no other ways be taken into the fortification; then the diſtance AD from the front of Pl. XVI. Fig. 1.

 the

the horn-work to the faliant angle A, of the ravelin or baftion, fhould not exceed 100 toifes, otherwife the branches cannot be well defended by the oppofite faces of the baftions or ravelins; they fhould only be about 80, as in this figure, if it may be done; the front EDF is 120 toifes; the perpendicular DC one fifth part of the exterior fide, that is, 24, and the faces 30; and fo in proportion to the exterior fide: the arc defcribed for finding the pofition of the retired flanks, fhould have a radius of 15 toifes, and the ditch 12; that the counterfcarp of the ditch may terminate at the extremity of the orillon which is but 5 toifes long, the flanks are as much retired, and made in the fame manner as thofe in the body of the place: we have added rams-horns inftead of tenailles, in order to get as much flank as could be.

The branches of the horn-work terminate on the faces of the baftions within 30 toifes of the fhoulders, the ditch is 12 toifes, the parapet of the horn-work is 12 feet high, as well as that of the ravelin which is conftructed in the manner defcribed before; that is, by defcribing an arc from the angle of the flank through a point in the faces of the hornwork, 12 toifes diftant from the fhoulder, whofe

whoſe interſection with the perpendicular CD produced, will give the ſaliant angle of the ravelin; the faces terminate within 3 toiſes of the ſhoulder; the ditch of the ravelin is but 8 toiſes; the retrenchments S are conſtructed by producing the branches, and the counterſcarp of the ditch before the ravelin, till they meet; and by ſetting off 25 toiſes on that counterſcarp, for the firſt, and 20 more for the ſecond; then if from the point O, as center, arcs are deſcribed through theſe points, which meeting the branches will give the other points through which the retrenchments paſs; they are made of earth only, their parapets ſhouldbe but 9 feet higher than the level ground, with a berm of 6 or 8 feet, and a dry ditch of 4 toiſes before them.

The diſtance A B or radius of the arc, which paſſes through the points C, B, D of the crown-work, is 100 toiſes, and ſhould not exceed 120 or 130 at moſt; the exterior ſides BC, BD are 100 likewiſe; the perpendiculars 20, that is, one fifth of the exterior ſides; the faces 26; the radius of the arc, which ſerves to determine the poſition of the flanks, is 15, and the ditch 12; the branches terminate on the faces of the baſtions within Fig. 2.

30 toiſes of the ſhoulders, in the ſame manner of thoſe of the horn-hork; the ravelins are conſtructed in like manner as in the horn-work; as likewiſe the retrenchments S, except that the firſt is only 20 toiſes from the great ditch.

Remarks on this conſtruction.

The branches of theſe works are more directly defended by the faces of the baſtions, than thoſe which are uſually made; the flanks much larger, and covered by the orillons, and the rams-horns added to the flanks, make together a larger battery than can be erected againſt them, which is a maxim in fortification, to be obſerved, if poſſible; otherwiſe the flanks are ſoon deſtroyed, the faces become defenceleſs, and ſo the work may eaſily be taken.

It is to be obſerved, that there ſhould be a row of paliſades placed in the middle of the dry ditches before the retrenchments S, and the parapets of theſe retrenchments ſhould be a row of paliſades placed about 3 feet above the berm horizontally, or rather with the points a little downwards, that the grenades may roll off into the ditch. For,

For, if this precaution is not taken, the enemy might pursue and follow the troops which defend these works, so as to enter with them into the retrenchments, and thereby get masters of them at the same time the horn-work is taken.

Because the retrenchments S making equal angles with the branches, and the counterscarp of the ditch before the ravelin, they will defend the level ground before them in the most direct manner, as we have shewn in the construction of our flanks, and therefore is preferable to any other position that can be given to these retrenchments.

The reader will easily imagine, that there must be a barrier or gate in the ditch near the branches of the horn or crown-work; likewise a sally port under the parapets, for the troops to retire through, when the work is taken.

Construction of a place with detached Bastions.

As a garrison seldom or never suffers the enemy to make an assault on the bastions when they are joined to the place, for fear of being put to the sword, and the town sacked,

ſacked, the baſtions are never capable of making a defence anſwerable to the expence of building them; it cannot therefore be ſaid, that ſuch a place anſwers the intent for which it was fortified.

It was for this reaſon, that M. *Vauban* invented his ſecond and third methods, as we have already mentioned in their conſtruction: but as his tower-baſtions will hardly anſwer the great expence of their building, we thought it would not be improper to propoſe two methods, of the ſame nature, in which it has been endeavoured to make every part anſwerable to the expence of building them; as likewiſe to diſpoſe them in ſuch a manner, as to make the beſt defence that they will admit of.

Pl. XVII. Let the interior ſide AB of an octagon be 130 toiſes; take Ab, Bn, equal to 12 toiſes, for the ſemi-gorges of the ſmall baſtions, and as much for their capitals Ac, Br, from the points c, r, draw the lines cn, rb to the extremity of the gorges, and make the flanks bd, nm perpendicular to the lines of defence; the ditch is 6 toiſes at the ſaliant angles c, r, and its counterſcarp drawn to the extremities of the flanks of the detached baſtions.

The

Plate XVII.

First Method with Detached Bastions.

Müller delin.

J. Mynde sc.

The capitals c C, r D of the detached baſtions are 55 toiſes, and the lines of defence are drawn to the extremities b and n of the interior flanks; 18, faces are 60; the radius of the arc, which ſerves to determine the poſition of the flanks, 18, and the ditch 16 at the ſaliant angle.

The ravelin is conſtructed, by deſcribing an arc from the extremity of the flank, as center, through a point in the oppoſite face of the baſtion, within 20 toiſes of the ſhoulder, which arc interſects the capital of the ravelin at the ſaliant angle; the faces terminate within 5 toiſes of the ſhoulders, the ſemi-gorge of the redoubt R is 15, its faces parallel to thoſe of the ravelin, and its parapet 2 toiſes; the ditch of the ravelin 12, and that of the redoubt 6.

The ſemi-gorges of the places of arms are 20 toiſes, thoſe of the ſtone redoubts p within them 12; the faces of the places of arms are 25; and thoſe of the redoubts, parallel to them, with a dry ditch of 3 toiſes before them; the covert way is 6, and the glacis 20.

The faces of the tenailles are 16 toiſes, the paſſage between them and the flanks of the baſtions 3; their flanks are parallel to the

the others, the curtain is drawn through the points where they meet the lines of defence, and the inside of the tenailles is terminated by lines drawn through the extremities of the flanks of the detached bastions.

Remarks on this construction.

This method answers perfectly the intent for which M. *Vauban* has invented his second and third methods; for the small bastions are more extensive than the tower bastions, and yet cost much less in their construction; and tenailles adding a lower flank to that of the detached bastions, renders there fire superior to that of the besiegers; and to secure the lower flanks from the enfilades, a part of the faces, next to the shoulders, should be raised about 3 feet higher than the rest, for the space of 4 or 5 toises.

The town wall should be of the same height, and no more than the detached bastions and ravelin; for which reason we made them all 15 feet high, the tenailles 3, and the ditches 12 feet deep; and if the works were only 12 feet high, it would be sufficient.

It

It is the opinion of some modern engineers, that if all the works were of the same height, it would be much better, than to make the inner ones so as to exceed those before them by 8, 10, or 12 feet, as is customary.

For it is evident that those high walls increase the expence prodigiously, and may be battered at a great distance; so that before the enemy have carried their approaches near the place, all the defences are ruined; which will not happen, if a work cannot be discovered till that which is before it is taken.

It is said that when the works exceed each other in height, the enemy can be fired at from all at them at once; but this is of no advantage: for they may raise batteries at 300 toises distance from the place, and from thence dismount all the guns; which being continually kept playing, will prevent the garrison from erecting new batteries; and the guns being once dismounted, the fire of the small arms can produce no great effect against the trenches.

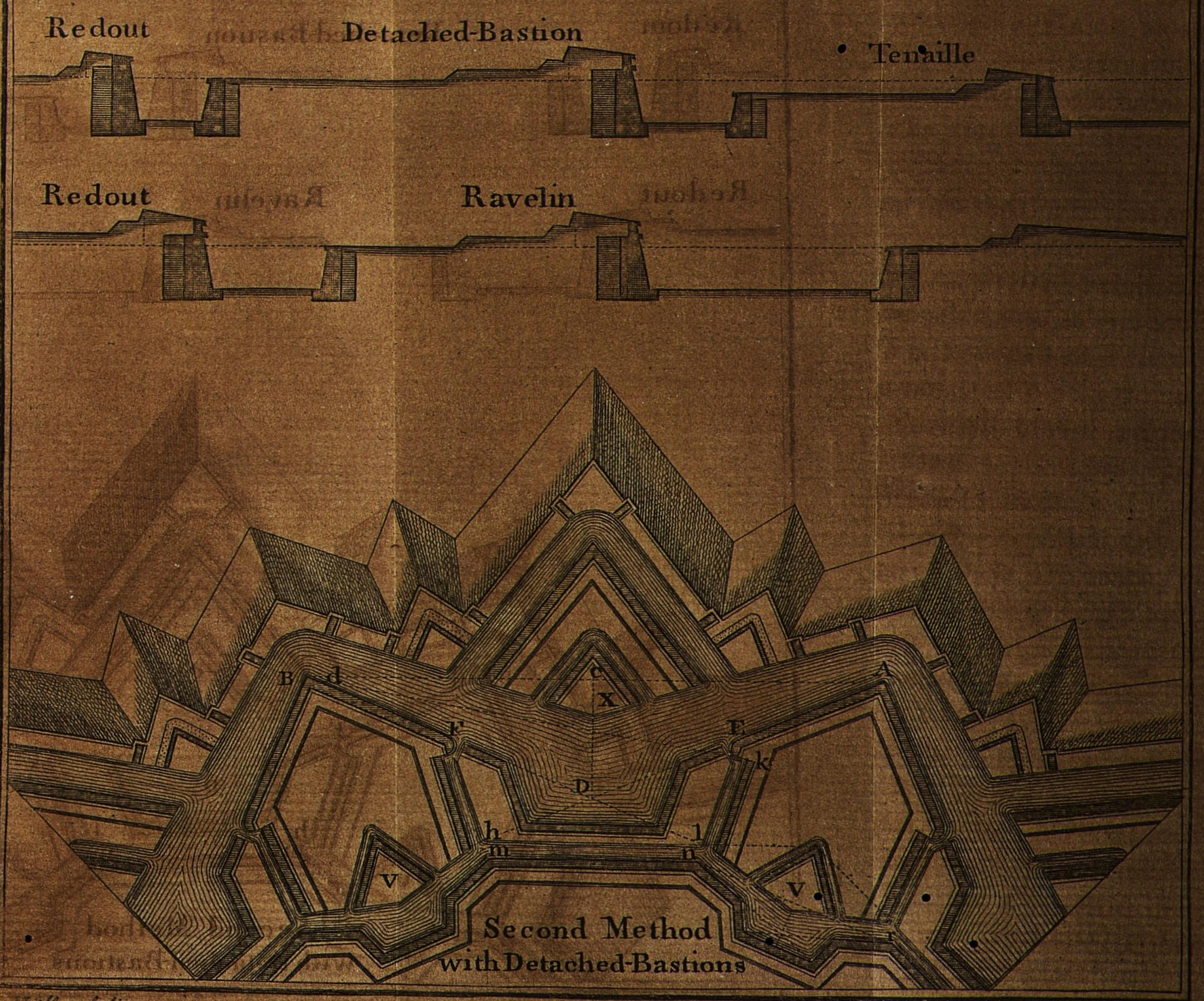
Instead of which I would chuse to place ugns in the places of arms, and keep them there till such time that the covert way is in danger of being attacked, and then remove them

them into the inner works, and ſo from one to another, till into the body of the place; for if the guns in the baſtions, or counter-guards and ravelin, are not diſmounted till ſuch time the covert-way is attacked, it will be a difficult matter to get and remain in poſſeſſion of it.

All the objection that can be made againſt low walls, is, that they are eaſily enfiladed by the ricochet batteries; to avoid which, the ſaliant angles of all the works ſhould be raiſed about 4 feet above the other parts, for the ſpace of 5 or 6 toiſes on each ſide; and the rampart ſhould likewiſe ſlope towards the place by 2 or 3 feet: this has been done by M. *Vauban* at *New Briſach*, and by M. *Coehorn* at *Bergen-op-zoom*; which being the laſt places that theſe great men have fortified, is ſufficient to determine others to follow their examples.

The redoubt p in the place of arms, ſhould be a wall of 3 feet thick only, with loop-holes, and no higher than the glacis, or rather two feet lower, ſo that they cannot be diſcovered but from the ridge of the glacis; the inſide of them may be 2 or 3 feet lower than the reſt of the covert-way, and ſo as to ſlope towards the ditch, that if any grenades

Plate XVIII.



Müller delin.

J. Mynde sc.

grenades or ſhells ſhould fall into them, they might roll into the ditch.

The redoubts R in the ravelin ought to have a parapet of 12 feet thick only, as being ſufficient to oblige the enemy to raiſe a battery in the ravelin to deſtroy it, which is all that is wanted; they ſerve to retire into when the ravelin is taken, and obſtruct the lodgments there; from whence the troops may retire into the body of the place, when they can hold out no longer.

As to the flanks, they are ſo diſpoſed as to defend the ditch in the beſt manner poſſible, and ſince the detached baſtions are wide and ſpacious, a third flank may be added, if it is thought neceſſary.

Conſtruction of a place with detached Orillon Baſtions.

Let the exterior ſide AB of an octagon Pl. XVIII. be 200 toiſes, the perpendicular CD 40, that is a fifth part of the exterior ſide, the faces AE, BF 55; the radius of the arc, which ſerves to determine the poſition of the flanks, 22; the ditch 16 at the ſaliant angles; the orillon 5; the flank is retired 5 toiſes; and the line k d, which terminates the flanks, is drawn

drawn from a point d in the face, at 5 toiſes from the ſaliant angle: the ſhoulders of the tenailles are 20 toiſes from thoſe of the baſtions; the flanks parallel to the others, and the curtain is drawn through the points of interſection of the flanks and lines of defence.

Take on the lines E l, F h, drawn from the extremities of the faces parallel to the flanks, and which terminate the inſide of the tenailles, the parts l n, h m, each of 6 toiſes, for the breadth of the ditch; and upon the exterior ſide r n, conſtruct a front of a polygon by making the perpendicular 12, and faces 20 toiſes.

The redoubts V are made of a wall 3 feet thick only, with loop-holes, their ſaliant angle is determined by the counterſcarps of the inner ditch produced, and the faces terminate within three toiſes of the ſhoulders; the ditch about theſe redoubts is 4 toiſes.

The ravelins and covert-way are conſtructed in the ſame manner as thoſe in the former method.

Remarks.

This method being more expenſive than the former, has the advantage in proportion; the

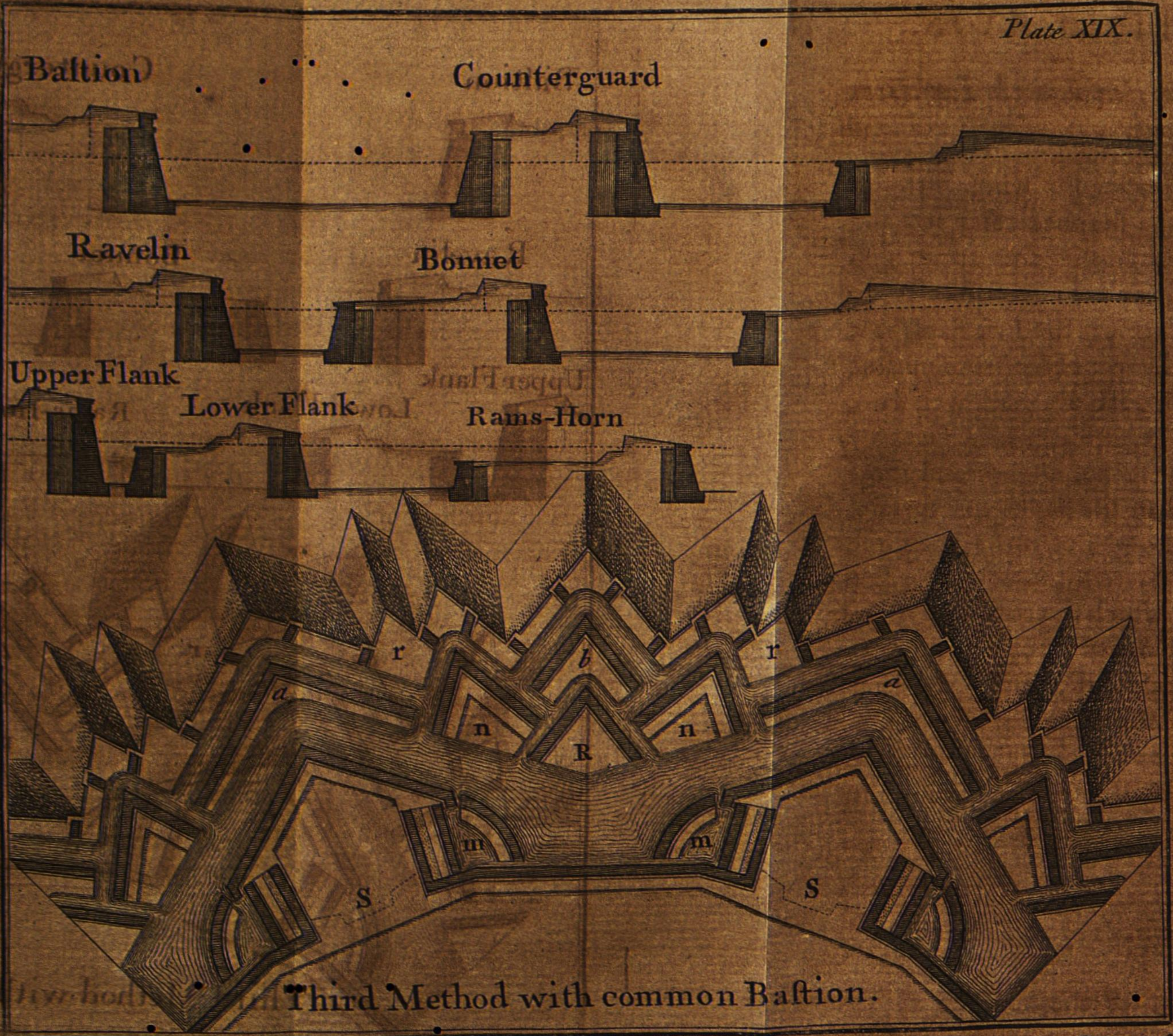
the ditch is defended by large double flanks, which will hold more guns than the enemy can oppoſe; for we ſuppoſe the body of the place and the detached baſtions to be but 3 feet higher than the glacis, that is, 10 feet above the level; ſo that the flanks cannot be diſcovered but from the ridge of the glacis; the redoubts V are of ſpecial uſe to retire into when the detached baſtions are taken, and to obſtruct the lodgments there; and as the communication from theſe redoubts into the body of the place cannot be ſeen from any part, this ſafe retreat is of great advantage; for by this means the troops will be able to maintain their ground to the laſt extremities; neither can the flanks of the inner front be diſcovered but from the level ground of the tenailles, which therefore I would make but a foot above the water in the ditch, ſo that there will not be a ſufficient quantity of earth to raiſe a battery.

If the flanks and faces of the tenailles were arched and open behind, it would be much better, for by that means the enfilading them would be impoſſible, neither would the ſhells have any effect upon them; and then the upper flanks might be made two or three feet lower than the faces, which

would prevent the enfilading them by the ricochet batteries; but if this ſhould be thought too expenſive, I would make the upper flank 7 feet above the level, that is, 2 feet lower than the faces, and the lower one 3 feet above the level; but then the faces of the tenailles muſt be 4 feet higher than the flanks, to cover them from the enfilades: for it is of the greateſt importance to prevent the enfilading the works as much as poſſible, ſince it is much more dangerous than to be ſeen in the front, and it is too dangerous to defend ſuch a work: this and the ſecuring the retreats from one work into another, are the two greateſt advantages to be gained in a good fortification; and for which the ſtone redoubts in the places of arms, in the detached baſtions, and thoſe in the ravelins, are all that can be done; for when thoſe works can be no longer defended, the beſieged watch their opportunity in the dark, or when the enemy's fire ſlackens, to croſs the ditch and retire; for it would be imprudent to defend them to the laſt; and there ſhould be mines to blow them up, when they can be of no further uſe.

Con-

Plate XIX.



Third Method with common Bastion.

Müller delin.

J. Mynde sc.

Construction of a Place with Lunettes and Counterguards.

This figure is an octagon, whose exterior side is 200 toises, the perpendicular 30, and the faces 55; the radius of the arc which terminates the position of the flanks is 20 toises, the orillons are 5; the first flank is 5 toises retired, and the second 10 from outline to outline; the rampart of the lower flank is 4, and the ditch behind it 3; the faces are feet higher at the saliant angles, and three at the shoulders, than the flanks and curtain, and that excess should be of turf: the ditch is drawn from the extremities of the orillon parallel to the line which serves to determine the position of the flanks; the tenailles, or rams-horns m, are described from the point of intersection, of the line of defence produced, and a perpendicular to the faces produced 3 toises; and they are terminated by a line 3 toises distance from, and drawn parallel to the curtains. Pl. XIX.

The semi-gorges of the ravelins R are 20 toises, their capitals 30, and the ditch before them 6.

The semi-gorges of the lunettes n, the one is 15, and the other 30 toises; and the

faces are drawn perpendicular to thoſe of the ravelin and the baſtions, the ditches before them are 8 toiſes.

The counterguards *a* are 7 toiſes broad at their extremities, and the faces perpendicular to thoſe of the lunettes, or parallel to thoſe of the baſtions: the ditch before them is 10 toiſes.

The bonnet b before the ravelin is 10 toiſes broad at the ends, and its faces are parallel to thoſe of the ravelin, or perpendicular to thoſe of the lunette: the ditch before this work is 10, the covert way 6, and the glacis 20; the places of arms r, are found by ſetting off 20 toiſes one way, and the perpendicular drawn through that point, meeting the face of the lunettes produced.

Remarks on this conſtruction.

As all the defences of this place are direct, that of a ravelin excepted, the works will be in a condition of making as great a reſiſtance as can be expected; the curtain, ravelin, lunettes, and bonnet, ſhould be all of the ſame height; as likewiſe the counterguards and baſtions, ſo that the baſtions may not be ſeen but from the counterguards,

where

where there is not ſufficient room for making batteries to deſtroy the flanks; the rams-horns ſerve to ſally out into the ditch, when dry, or to harbour boats behind them when wet; their level ground ſhould not be above 4 or 5 inches above water, or even with the bottom of the ditch when dry; and as they cannot be enfiladed from any part, their grazing fire will extremely well defend the great ditch, and that before the ravelin; as likewiſe the level ground of the ravelin, lunettes, and counterguards.

The reaſon that the rams-horns are not continued quite to the curtain is, that the ſplinters from the wall may not hurt thoſe in the rams-horns, it ſaves likewiſe ſome expences, and this paſſage may ſerve in a wet ditch for boats to go out and come in, and the part between the lower flank and the rams-horn ſerves as a ſafe harbour for the boats, or as a place of arms when the ditch is dry.

Although theſe baſtions are of as great a defence as poſſible, yet the enemy will in time be able to ruin the flanks, and make breaches in the faces; and this being once accompliſhed, the garriſon will be obliged to ſurrender, unleſs ſome other defence be

 found;

found; for which reaſon, good retrenchments, ſuch as marked S, ſhould be partly made, either at the ſame time that the place is built, or in time of peace, with a good ſtrong wall and a ditch before it; as likewiſe with countermines under them, to prevent the enemy from blowing them up with their mines; and from the bottom of this ditch, galleries might be carried on under any part of the baſtion, to blow it up, when it can be defended no longer above ground. I ſaid that theſe retrenchments ſhould only be partly made; becauſe, there muſt be about 4 toiſes left unfiniſhed at each end near the flanks, in order that there may be ſufficient room behind the flanks to place cannon; and when the attack is once made, the parts next to the flanks, which are of no uſe, may then be finiſhed, and the other afterwards, when the flanks are of no further uſe: by this means the baſtions will be able to make as great a defence, as if they were detached.

For it is in vain to pretend that a place ſhould make a long and ſtout defence, though ever ſo well fortified, if the governor either wants means, or does not know how to defend it; and there ought not to be a ſingle work

work but what ſhould be defended inch by inch, and when the works are ſpacious enough to admit of retrenchments, there ſhould be as many made as can be done: the works muſt not only be thus diſputed above ground, but likewiſe under ground; for all the parts where the enemy is likely or muſt make lodgments, ſhould be countermined, in order to blow them up when they can be no longer maintained above ground.

The expence of making countermines and retrenchments is inconſiderable, in reſpect to that of building the fortification, and yet they may lengthen the defence conſiderably. It appears ſhameful, that as ſoon as a breach is made in the baſtion, and often not wide enough to maſte an aſſault, the garriſon ſhould be obliged to capitulate; it ſeems that the baſtions, which are the moſt conſiderable part of a fortification, and coſt moſt, ſhould ſerve more as a ſhew than as a real additional ſtrength to the place; this is undoubtedly owing to the incapacity or ſlothfulneſs of governors, who think more by what means to make moſt money of their places, than how or in what manner the town is to be defended, and to provide in time againſt the dangers which may happen in an attack.

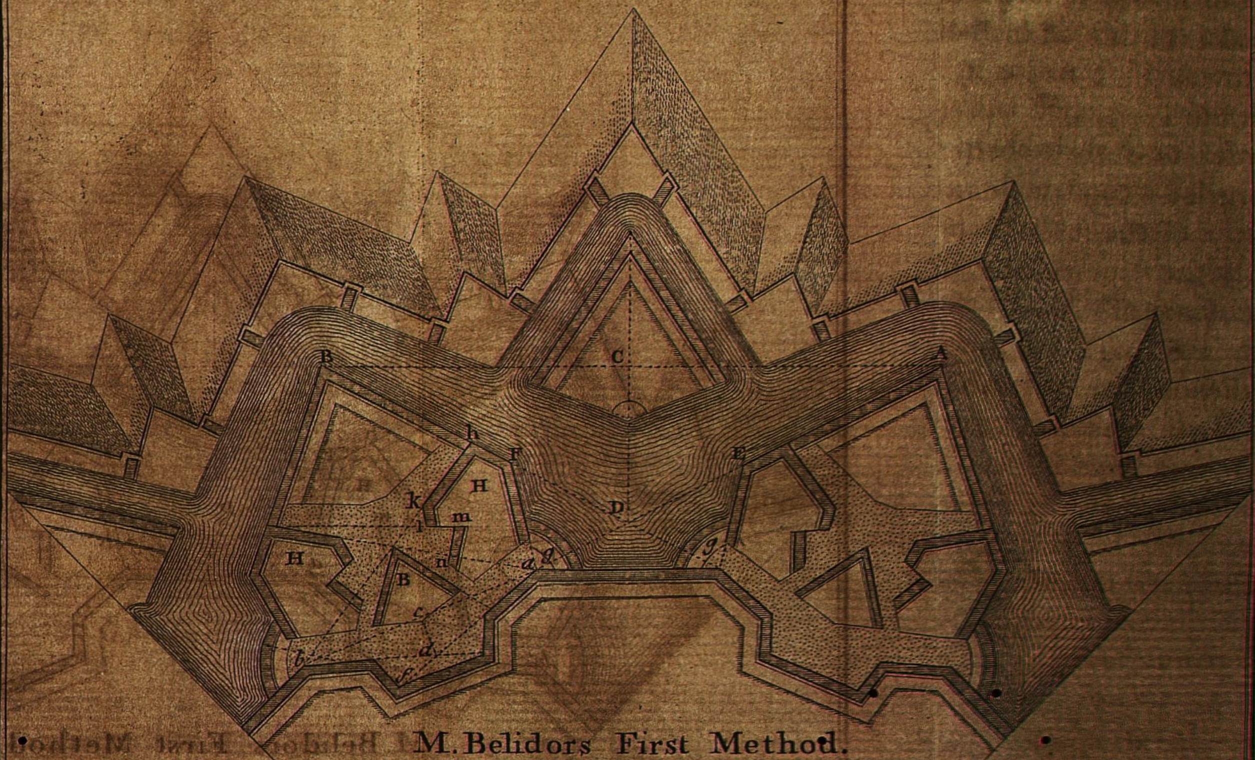
That a town may make a conſiderable defence, though moderately fortified, is no romantic fancy, as evidently appears by the ſieges of *Vienna* and *Candia*, when they were attacked by the *Turks*; there was not a foot of ground gained by the beſiegers, which the beſieged did not immediately cut off; the former made a defence of near three months till it was relieved, and would have continued ſo to the laſt inch of ground of the whole town, if it had not, and the latter held out ten years.

In order to form a better judgment of theſe three new conſtructions, we have added the profiles of the ſeveral works, and which are nearly the ſame as thoſe the *French* made uſe of in ſome of the laſt places they have fortified. Though we have uſed the octagonal polygon here, yet the ſame works will do in any other above an exagon with ſome very few variations in reſpect to the direct defence.

Conſtruction of M. BELIDOR's *firſt method.*

Plate XX. This figure is a part of an octagon, whoſe exterior ſide A B is 200 toiſes; the perpendicular

Plate XX.



M. Belidors First Method.

Müller delin.

J. Mynde sc.

dicular CD, 50; the faces AE, BF, 70; and the flanks are found according to M. *Vauban*'s method.

The line joining the extremities *a* and b of the flanks of the same baſtion, ſerves as an exterior ſide to trace the front of a polygon; whoſe perpendicular c d is 13 toiſes, the faces 22: the parts d f of the lines of defence, which terminate the flanks, are 14; the dry ditch before this front is 10 toiſes at the points *a*, b, and the counterſcarp terminates at the oppoſite ſhoulders.

The rams-horns *g*, are deſcribed from a point, in the middle of the faces of the interior front, as centers, with a radius of 25 toiſes.

The retrenchments H are drawn from a point in the face, at 15 toiſes from the ſhoulder to the points b, *a*, and are 25 toiſes long; the orillons k l, 8, and the flanks n m are 8 toiſes retired near the orillon, which are the chords of an arc from the oppoſite ſhoulders; the ditch before theſe retrenchments is 8 toiſes near the parapet of the baſtions, and its counterſcarp directed to the ſhoulders.

The ſaliant angle of the redoubt B touches the interſections of the curtains produced, and

and the faces terminate on the faces of the inner front within 3 toiſes of the ſhoulders; its ditch is 3 toiſes; theſe redoubts are a ſtone wall of 3 or 4 feet thick, with loop-holes in the faces.

The author having made no outworks to this ſyſtem, we have added ravelins and a covert way made in the uſual manner; the great ditch is twenty toiſes before the ſaliant angles of the baſtion, and its counterſcarp is directed to the ſhoulders; and the faces of the ravelins to the outline of the retrenchments H.

Remarks on this conſtruction.

This fortification has the advantage of all thoſe which have detached baſtions; the retrenchments within are of a good defence; but they take up too much ground, eſpecially the ditches, which ground might, in my opinion, be better diſpoſed of; beſides, if the breach was made at h F, by the guns placed in the oppoſite place of arms and ravelin, the beſiegers would find a lodgment H ready made, wanting only a part oppoſite to the face or the inner front. But the flanks of theſe large baſtions, which are

about

Plate XXI.

M. Belidor's Second Method.

Müller delin.

J. Mynde sc.

about 26 toiſes long, ſeem to be too ſmall, and the great ditch too large; for if it was only 15 or 16 toiſes at the ſaliant angles, and the counterſcarp directed to the flanks within 2 or 3 toiſes of the ſhoulders, the beſieged would not find ſo much room to place their counter-batteries.

The ditch before the inner front might be ſmaller, that is, of about 5 toiſes; and then the flanks would become ſo much the longer.

As the ditches before the retrenchments H are directly oppoſite to thoſe before the ravelin, the author deſigned to make a battery in them; for which he reaſon he carries that ditch through the parapet, and leaves only the walls to cover it; but as the enemy might ſoon deſtroy the wall, and therefore need make no other breach to enter the baſtion, we have continued the parapet, and thoſe batteries might be arched and open behind.

Conſtruction of M. Belidor's *ſecond method.*

This figure is again a part of an octagon, whoſe exterior ſide AB is 200 toiſes; the per- Pl. XXI.

perpendicular CD, 55, and the faces, AE, BF, 70, as in the former; and the flanks are likewiſe found according to M. *Vauban*'s method.

The line *ab*, which paſſes through the extremities of the flanks, ſerves as an exterior ſide to the inward polygon; whoſe perpendicular c d is 5 toiſes, the faces 24, and the flanks are chords of arcs deſcribed from the oppoſite ſhoulders of the detached baſtions as centers.

This inward polygon is nothing elſe but a ſtrong wall, behind the curtain of which, and of about 18 feet diſtant from it, is a parapet or epaulement of earth 3 toiſes thick; and within the baſtions are cavaliers, whoſe fronts are circular arcs deſcribed with a radius of about 23 or 24 toiſes; the flanks are 7 toiſes long, and gorges 32.

The counterſcarp of the ditch before this polygon is 7 toiſes at the ſaliant angles *a*, *b*, and parallel to the curtain.

The rams-horns or tenailles touch the lines of defence within 3 toiſes of the ſhoulders, and are deſcribed ſo as to meet the other lines of defence in the ſame point as the counterſcarp of the inner ditch.

The

The outline of the curtain between the rams-horns is 9 toiſes from the ditch.

The exterior ſide h k of the retrenchments within the detached baſtions, meets thefa ces within 20 toiſes from the ſhoulders; the perpendicular m n is 17, the faces h l, 20; the chord on which the orillon is deſcribed is 5 toiſes, as likewiſe the retired part of the flank i the flanks and orillons are made according to M. *Vauban*'s method.

The circular curtain and the round part of the ditch behind it, are deſcribed with a center, 25 toiſes diſtant from the points *a*, *b*.

The great ditch is 20 toiſes before the ſaliant angles of the detached baſtions, and is ſuppoſed to be dry; for which reaſon M. *Belidor* made a caponiere to go from the curtain to the ravelin, of 18 or 20 feet wide, whoſe parapets terminate on both ſides in a ſlope or glacis.

The capital of the ravelin Q is 66 toiſes, that of the redoubt P, 30; the faces of the ravelin are directed to thoſe of the retrenchments within the baſtion, and thoſe of the redoubt to the ſhoulders; the batteries in the ravelin are retired 8 toiſes behind the faces; the ditch of the ravelin is 12 toiſes, and that of the redoubt 7.

The

The ſemi-gorges of the lunettes R are 25 toiſes, and the faces perpendicular to thoſe of the ravelin and the baſtion; the ditch before them is 8 toiſes, and the batteries S are retired as much, and are 15 toiſes long: laſtly, the covert-way is 6 toiſes.

Remark on this conſtruction.

If the parapet behind the curtains, and the cavaliers in the baſtions, of the body of the place had been joined to the wall, it would have been much better, ſince the wall will ſoon be deſtroyed, and thereby open the place at once: the perpendicular of the great polygon is a great deal too long, it makes the baſtions too big and expenſive; the great ditch is likewiſe too wide; the earth taken out of it will be more than is required for raiſing the ramparts. As to the outworks, they ſeem to be extreamly well diſpoſed, and capable of a good defence, excepting the retired batteries in the ravelin Q are, for the greateſt part, covered by thoſe of the lunettes R; for which reaſon, lunettes diſpoſed in the manner repreſented in the 19th plate are, in my opinion, of a much better defence than theſe here; but the whole

Plate XXII.

M. Belidors Third Method.

Müller delin. J. Mynde sc.

whole work together is too expenſive to be ever made uſe of; for it would require almoſt a whole army to defend theſe works, and if we conſider the prodigious quantity of ſtores and ammunition required, one may eaſily perceive that this fortification will never be uſed.

Conſtruction of M. BELIDOR's *third method.*

This figure is likewiſe a part of an octagon, whoſe exterior ſide AB is 200 toiſes, the perpendicular CD, 40; the faces AE, BF, 55; the parts D r of the lines of defence, between the perpendicular and the broken part of the curtain, 30; and the length of the broken parts r n, 25; the orillon is 9, and is part of a flank found according to M. *Vauban*'s method; the flanks are 8 toiſes retired, and are arcs of 60 degrees; the outlines of the rams-horns are 13 toiſes diſtant from each other; the paſſages at their extremities are 3, the outmoſt or loweſt is deſcribed with a radius of 30 toiſes, and the other is deſcribed from the ſame center. Pl. XXII.

We

We have omitted the cavaliers placed in the gorges of the baſtions, as being according to our notion ſuperfluous.

The center R of the arc KL is 18 toiſes diſtant from the re-entring angle of the counterſcarp; the chord KL is 44 toiſes, as well as the other face of the lunette; and the radius RK, 88; the battery H is 10 toiſes retired.

The figure m is a redoubt made of a ſtone wall full of loop-holes, with a ditch of 2 toiſes before it.

The ditch before the lunettes is 12 toiſes at the ſaliant angles, and its counterſcap directed to the extremities of the oppoſite faces.

The capital of the ravelin W is 44 toiſes, the ſemi-gorges 31; the flanks are 9 toiſes, and directed to the ſhoulders of the baſtions.

The ditch before the ravelin is 10 toiſes, and the covert-way 6.

The glacis T, before the ſaliant angles of the baſtions, is 15 toiſes broad; the ſemi-gorges of the places of arms X are 26 toiſes; and thoſe of the redoubts, or ſtone wall within them, 20, reckoning from the edge of the glacis T; and the faces are drawn parallel to the oppoſite ſemi-gorges.

The redoubts S within the lunettes, are alſo made of a wall 3 or 4 feet thick, full

 of

of loop holes, with a ditch of 3 toises before them.

The dimensions of the arrows and detached redoubts, are the same as those in M. *Vauban*'s methods, only the arrows have flanks parallel to the passage of 10 toises.

Remarks on this construction.

M. *Belidor* commits the same faults in all his works, as almost all those who fortify upon paper only; by considering how a place might be strongly fortified, without troubling themselves about the expences of building, or the great number of troops to defend it; imagining, I suppose, that a Prince or State, should spare no expence to secure the subjects against a powerful enemy. If it were only for the expence of building them, I should be of their opinion; but when it is considered how much artillery and ammunition is required, together with the great number of troops to defend such places, it may easily be conceived, that their first notions must necessarily vanish into smoak.

But let us enter into particulars; the redoubts m are intended to secure a safe retreat from the lunettes when they are taken;

 but

but as the befiegers may eafily deftroy them with the fame guns placed in the oppofite ravelin, which ferve to batter the faces of the lunettes, as likewife the curtain of the body of the place, they will hardly anfwer the purpofe for which they were defigned; he fhould have added a parapet of 12 or 15 feet, which would have effectually fecured the retreat. The lunettes might have been conftructed fo as to defend each other directly, as likewife to be defended directly by the oppofite faces of the baftions; and if there had been made counterguards inftead of the glacis T, they would have covered the baftions and the oppofite flanks, and would not be liable to be taken fword in hand, as thefe works may be taken. I fuppofe the author intended to fecure them with pallifades, but when the pallifades are higher than the glacis, the befiegers guns will foon deftroy them, and make their defence more dangerous than ufeful; if they are equal in height with the glacis, and placed near the parapet, the enemy jumps over them; and if they are farther off, they are troublefome, and eafily deftroyed by the ricochet batteries; from whence it may be concluded, that thefe works are of little or no defence.

The

The places of arms are too ſpacious, and the counterſcarp of the ditches before the detached redoubts being parallel to the flanks, render the ditch before the faces defenceleſs, and therefore ſerve as retrenchments ready to receive the enemy, without requiring ſo much as a traverſe to cover them; the flanks of the arrows are made with no more judgment than theſe ditches.

The rams-horns are certainly very well contrived; they are much preferable to the tenailles; they cannot be enfiladed from any one place, reſiſt better, by their bending outwards, the enemy's batteries, and render the flanks much ſuperior to any battery that the enemy can raiſe againſt them; but the retired flanks have the ſame defect as thoſe of M. *Vauban*'s, which we have ſhewn before: it is ſurpriſing, that no author has ever obſerved the badneſs of theſe kinds of flanks; the great character which M. *Vauban* has juſtly acquired, has probably impoſed upon their underſtandings. The ſtone redoubts S, and X, in the lunettes and places of arms, are undoubtedly very good, they add much ſtrength to thoſe places, and ſecure a retreat to the troops which defend them.

Construction of M. Blondel's *method.*

Pl.XXIII. M. *Blondel* establishes two sorts of fortifications, *viz.* the great, whose exterior side he makes 200 toises, and that of the little 170; he begins with the angle made by the exterior sides and the lines of defences, for which he observes the following rules.

Subtract 90 degrees from the angle of the polygon, and take the third part of the remainder, to which add 15 degrees, and the sum will be the angle sought. For example, in an exagon, the angle of the polygon is 120 degrees; from which take 90, and there remains 30, the third part of which is 15; this added to 10, gives 25 for the angle required.

He makes likewise his lines of defence equal to $\frac{7}{10}$ of the exterior side; that is, 119 or 120 in the little, and 140 in the great; this being premised, the construction is as follows.

Let the exterior side A B of an exagon be 170 toises; the angles ABC, BAD, 25 degrees each; the lines of defence AD, BC, 120 toises; let O be the point of intersection

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Plate XXIII.
Count Pagan's First Method.
B
A
Pagan's 2d Method.
T
V
A
B
T
Blondel's Method.
V
a
E
I
C
O
D
L
H
V
B
Count Pagan's Method Corrected.
Müller delin.
J. Mynde sc.

section of these lines, bisect AO, BO in E and H; then will AE, BH be the faces, EC, HD the flanks, and CD the straight part of the curtain.

The orillons EI, LH, are 10 toises each, the flanks are retired 5 toises behind the lines EC, HD; in all ploygons above an eptagon, he makes the retired flanks from 10 to 12 toises distant from these lines, in order to lengthen the curtains.

Each flank exceeds the flank before it 9 feet in height, and they are 8 toises distant from outline to outline.

The counterscarp of the ditch is drawn from the extremities I, L of the orillons, parallel to the faces of the bastions: the counterguards are but 4 toises broad, 10 or 12 feet of which are taken for the parapet; the ditch before them is 10 toises.

If from the shoulder E, as center, there be an arc described through the shoulder H, and from H through E, their intersection will be in the saliant angle of the ravelin, the faces of which are directed to a point in the faces of the bastions within 6 toises of the shoulders; the gorge of the ravelin is determined, by producing the faces of the counterguards; the ditch of the ravelin is 12 toises.

The ſemi-gorges of the lunettes V, are 20 toiſes: the faces are parallel to the counterſcarps of the ditches; before the ravelin and counterguard, and the ditch before them, is 8 toiſes; the covert-way 6, and the faces of the places of arms, which are likewiſe parallel to the counterſcarps, are as much.

The retired batteries *x*, in the baſtions and ravelins, are 7 toiſes from the faces; and their lengths are determined by the faces and counterſcarps produced of the ravelin and counterguards.

Remarks on this conſtruction.

M. *Blondel* was undoubtedly a great man in his time, and had travelled all over *Europe* and *America*, where he made very good obſervations of all the different manners of fortifying, by the ſeveral nations, as appears by his ſmall treatiſe on fortifications.

Notwithſtanding his great ſkill in diſcovering the faults committed by others, and endeavouring to avoid them, yet he fell into others of much more conſequence; neither did he conſider the great expence his method

muſt coſt, (which is the caſe of moſt authors) and likewiſe the numerous artillery required to defend it.

However, if the works were of good defence, he might be excuſed in neglecting the expence; but how far he has ſucceeded in that reſpect, we ſhall make appear.

He imagines, that places are generally loſt for want of having ſufficient flanks, for which reaſon he makes three, one behind another; but they are too near each other, ſo that the rubbiſh of the upper flank muſt certainly deſtroy the uſe of the lower: beſides, if any ſhells fall into the lower ones, they muſt inevitably deſtroy the troops that are there, as not having room enough to avoid them; they are likewiſe too open, and ſo more liable to being deſtroyed from the covert-way, for the counterguards are not broad enough to ſcreen thoſe flanks, as the author imagines; ſince a few mines will ſoon deſtroy them, as we have obſerved in M. *Coehorn*'s method, who made his after M. *Blondel*.

The low batteries *x*, are likewiſe too narrow and too much confined; though they might have been of good defence, before the ſhells were ſo much uſed, which was

perhaps the caſe, when this method was invented.

Had M. *Blondel* known the uſe of ricochet batteries, he certainly would not have omitted the traverſes in the covert-way as he does; his places of arms are too ſmall to make any tolerable defence.

His great ditch is too wide by much, for it is at leaſt 25 toiſes before the faces of the baſtions; for the expence of removing the great quantity of earth out to them, to a great diſtance, is both idle and needleſs.

Conſtruction of Count PAGAN's *method.*

This author eſtabliſhes three ſorts of fortifications, *viz.* the great, mean, and little, whoſe principal dimenſions are contained in the following table.

TABLE.

TABLE.

	Great Fortification.		Mean.		Little.	
	Square	In all the other Pol.	Square	In all the other Pol.	Square	In all the other Pol.
Exter. Sides.	200	200	180	180	160	160
Perpendic.	27	30	24	30	21	30
Faces.	60	60	55	55	45	50

Let the exterior ſide AB of an octagon be 180 toiſes, the perpendicular 30, and the faces 55; draw the flanks perpendicular to the line of defence, which biſect by a line drawn from the oppoſite ſaliant angles; the one half ſerves for the orillon, the firſt flank Pl.XXIII.

flank is 5 toiſes retired behind the orillon, the others are 7 toiſes diſtant from outline to outline; the faces of the cavaliers in the baſtions are parallel to thoſe of the baſtions, and 13 toiſes diſtant from them.

The great ditch is 16 toiſes, and its counterſcarp parallel to the faces of the baſtions; the capital of the ravelin 50, and its faces are drawn to the ſhoulders; the ſemi-gorges of the redoubt within the ravelin 15, and the faces paralell to thoſe of the ravelin; the ditch of the ravelin 12, and that of the redoubt 6; the ſaliant angle of the counterguard is 40 toiſes diſtant from that of the baſtion, and 9 or 10 broad at the extremities; the ditch before the counterguard is 12, which is the ſame as that before the ravelin; the covert-way 4, and the faces of the places of arms 8, and are parallel to the oppoſite counterſcarp.

The author makes other outworks, as in his ſecond method, where the counterguards T are 25 toiſes broad; they are joined by a crooked curtain, taken in the faces produced; the diſtance AB between the inward and outward flank is 17 toiſes, and divided into three equal parts, for the three

three flanks; the capital of the ravelin V, is here but 35 toises, and the faces directed to the shoulders of the counterguards; the ditch before the ravelin is 9, the rest is the same as in the first construction.

All the ramparts are 7 toises broad, out of which 3 are taken for the thickness of the parapets; in the square the lower flank is taken in the same line with the orillon, but in all the rest they are 5 toises retired behind it.

The flanks exceed each other 12 feet in height; the great ditch is 18 deep, and the body of the place is 36 high, taken from the bottom of the ditch; the ditches of the ravelins and counterguards are 12 deep; and their ramparts are 24 high from the bottom of the ditch; so that the height of the body of the place exceeds that of the outworks but by 6 feet.

The great advantage that this method had above all those which appeared then, has gained the author a great reputation, and his first system has been used in several places; and though this is the only author who has given the true position to his flanks, yet he has been found fault with on that very account, as being too much exposed, and too easily ruined by the enemy's counter-batteries,

ries; most authors take it for a general maxim that the direct defence is the best; and we have proved it in the beginning of this section; and yet a late *French* author, who takes *M. Vauban* to be his hero, says, *that if they were not so direct, they would be no less good, and it is not necessary here to observe a geometrical exactness*; but how this author reconciles his manner of arguing with the above-mentioned general maxim, is a thing I do not understand; for if this maxim is not to be followed, it should not be mentioned: and if exceptions are to be made in certain cases, it is not general.

This author blames likewise Count *Pagan* for making his orillons equal to half his flanks; by which means he says, there is so much of the flanks lost, and a lesser orillon would have been sufficient: in which he is mistaken, for there may be 4 guns placed upon the orillon; and if the Count made his retired flanks but half the straight flanks, it is because he thought that there is room enough to place as many guns in them as are necessary to defend the ditch; and by doing so, they were better hid, and not so easily dismounted by the besiegers: it is certain, that his flanks are too near one another, and if there

there were but two in polygons under an octagon, it would have been much better; the ditch before the redoubt is but ill defended, which ſhould never be made without making tenailles likewiſe; ſo that it might be defended from thence.

We have ſaid that his ramparts are but 7 toiſes in general, ſo that the parapet, which is 3, being taken from 7, there remains but 4 toiſes or 24 feet for the free paſſage and batteries, which is too little; becauſe the platforms take up 18 or 20 feet, ſo that there remains not room enough to paſs by with another carriage. M. *Vauban* made the level ground of his ramparts 30 feet, and ſometimes more, in moſt places he fortified, though in his conſtruction but 4 toiſes or 24 feet; but as he never publiſhed any thing himſelf, thoſe that have given his works to the public have, I ſuppoſe, ſubſtituted their own dimenſions.

His covert-way ſeems to be too narrow, and the places of arms too inconſiderable, for defending the glacis; the not making traverſes in the covert-way, is likewiſe a great miſtake; but as the ricochet batteries were not known in his time, there was not yet ſo much occaſion for them then, as there is now.

The

The counterguards in his ſecond method are too ſpacious; his propoſing to build hoſpitals, ſtore-houſes and magazines in them, muſt prove a great detriment to their defence, unleſs thoſe buildings are demoliſhed when theſe works are attacked.

Count PAGAN's *method corrected.*

The exterior ſide of this octagon is 200 toiſes, the perpendicular 30, the faces 60, the orillon 5; the firſt or loweſt flank is 4 toiſes retired behind the orillon, the flanks are 12 toiſes diſtant from outline to outline; the great ditch is drawn from the extremities of the orillons, parallel to the faces of the baſtions; the ravelins are made in the manner deſcribed in plate XV.

The ſaliant angle of the counterguards is 35 toiſes diſtant from that of the baſtions, and they are 8 toiſes broad at their extremities, the ditch 12; there ſhould be retrenchments made in the counterguards, perpendicular to the middle of the faces, with a ditch before them of 3 or 4 toiſes.

The covert-way is 6 toiſes, the ſemi-gorges of the places of arms 20, and the faces are perpendicular to the counterſcarps.

Remarks on this construction.

All the works in this fortification have a very good defence; the compactness of the works, and the little expence, in respect to the extent of the town, makes this method far preferable to any other.

For we suppose the town wall no higher than the counterguards and ravelins, so that a line drawn from the inside of the parapet of the body to the extremity of the glacis, determines the heights of the counterguards, ravelin, and the ridge of the glacis.

We have made but two traverses in each branch of the covert-way, but because of their length, there may be made three, to prevent better the enfilades of the ricochet batteries; these traverses need not be so thick as they are generally made, for 10 or 12 feet would be sufficient to resist the ricochet batteries.

As the flanks are here pependicular to the lines of defence, it was necessary to make the counterscarp of the great ditch parallel to these lines, according to what has been said with respect to the true position of the flanks, at the beginning of this section.

If

If the lower flanks were arched and open behind, in all places that have two or three, it would be much better, since this would effectually prevent the enfilading them, when they are not covered by orillons; they would likewise be out of danger from the shells, especially when there is a ditch behind, and the level ground goes sloping towards the ditch.

SECT. III.

Of irregular Fortification.

THE most essential principle in fortification, consists in making all the fronts of a place equally strong, so that the enemy may find no advantage in attacking either of the sides; this can happen no otherwise in a regular fortification situated in a plain or even ground; but as there are but few places which are not irregular, either in their works or situations, and the nature of the ground may be such as makes it impracticable to build them regular, without too great expence; it is so much the more necessary to

shew

shew in what consists the strength or weakness of a town irregularly fortified, so that the weakest part may be made stronger by additional outworks; as likewise, if such a place is to be attacked, to know which is the strongest or weakest part.

All the authors who have wrote on fortification, that I have seen, are so deficient in regard to this, that not the least knowledge can be gathered from their writings; they do not even mention any thing about it. From whence it seems to appear, that there can be given no general rule, whereby the strength or weakness can be discovered; and if we consider the several attacks that were made in the late wars, one would be inclined to think, that the engineers were no ways acquainted with it. A late author has mutilated what is here said, and enlarged upon the subject very much; he had the assurance, not to say worse, to persuade the public, that all was his own invention, as if this work had not been known before his; but his whole performance consists in nothing else than a heap of absurdities.

That M. *Vauban* understood irregular fortification perfectly well, is plain from those places he has fortified of that kind; and yet

his commentators mention nothing of it; they very often laviſhly beſtow their praiſes on ſome of his works which do not deſerve it, and are ſilent upon thoſe which are very juſtly to be eſteemed.

When the ſituation of a place is ſuch that it cannot be regularly fortified, it ſhould be contrived to make it nearly ſo; that is, inſtead of inſcribing it in a circle, it ſhould be inſcribed in an oval, ſo that one half may be like and equal to the other half; and when this cannot be done, it ſhould be made as regular as it poſſibly can be, and as much as the nature of the ground will admit of.

But to reduce irregular fortification into ſome form, that from thence their perfections and imperfections may be diſcovered; we ſhall ſuppoſe, in the firſt place, that one half; of the place is equal and like the other half; and then ſhall ſhew the application of this principle in all ſorts of irregular places.

Proposition.

Pl.XXIV. If a fortification be inſcribed in an oval, that is, if the one half is equal and like the other half; I ſay, that the ſides CD, GH,

on

Plate XXIV.

on the flat parts, are ſtronger than the ſides AB, EF, on the narrow parts, ſuppoſing all the exterior ſides equal, and the place equally fortified.

It muſt be conſidered, that a front may be eſteemed more or leſs ſtrong, in proportion as the beſiegers are obliged to make more or leſs works in their approaches; and when theſe approaches; are ſuch, as being produced, ſhall always fall without the fortification, otherwiſe they may be ſeen in front by ſome of its parts; therefore when the angles BCD, CDE of the polygon are very great, and the beſiegers come within a ſmall diſtance of the works, they cannot approach any nearer without being ſeen in front, excepting by a direct ſap, with traverſes; and as this way of approaching preſents but a ſmall front, the beſieged, who have a much larger, may oppoſe what obſtacle they pleaſe.

And on the contrary if the angles HAB, ABC of the polygon are very ſmall, the beſiegers may carry on their approaches to the very counterſcarp, and have always a larger front than the beſieged.

Moreover, as the beſiegers muſt extend their approaches to three fronts, whether

they are ſmall or large, the work of the approaches before the front BCDE, will be to the work before the front HABC, as the line BE is to the line HC nearly; that is, as the greater axis of the oval is to the leſſer: conſequently the front CD on the flat ſide, is ſtronger than the front AB on the narrow ſide.

COROLLARY. I.

Hence it follows, that the longer the exterior ſide CD of a polygon is, provided the lines of defence are within the reach of muſket-ſhot, and the angles BCD, CDE of the polygon the ſame, the ſtronger the front will be; ſince the works become more ſpacious, may hold more troops to defend them, and the beſiegers are obliged to extend their trenches farther.

COROLLARY II.

It follows likewiſe, that the greater the angles of the polygon BCD, CDE are, the exterior ſides being the ſame, the ſtronger the front CD will be; becauſe the length of the line BE increaſes, and the extent of the

the besiegers approaches in proportion, as has been proved in the foregoing proposition; consequently the strength of a fortification increases in proportion to the number and length of its sides; that is, a dodecagon is stronger than an octagon, supposing the length of their sides equal; and an octagon, whose sides are 200 toises each, is stronger than another octagon, whose sides are only 180; and hence a right line fortified, is the strongest of all, contrary to the opinion of most engineers: there are even some, who imagine precisely the contrary to be true.

Mr. *Villeneuve*, a French author, at the end of his regular fortification says, that if, instead of fortifying a regular octagon in the usual manner, a square was made so as the sides are equal to 360 toises, or double the sides of the octagon; and making flat bastions in the middle of these sides, so as three bastions being placed in a right line, the faces being 50 toises, and the perpendiculars 22 toises and 3 feet, which is one eighth of the exterior side; this figure would be more advantageous than the octagon fortified in the usual manner.

As the angular baſtions are weaker than the others by what has been proved before, he would have counterguards made before them, and their gorges retrenched, as likewiſe tenailles in the ditches: if this method be conſidered with attention, it will appear not altogether uſeleſs; for as the attack is reduced to the four angular baſtions, they may be well ſecured by outworks, with leſs expence than the common octagon; for if inſtead of making tenailles, I would make rams-horns next to the flat baſtions only in, order to increaſe the defence of the angular baſtions, and if ſmall lunettes were added next to the counterguards, ſo as to defend their ditches, it would encreaſe the defence conſiderably. This fortification has another advantage, which is, that the inſide may be filled with regular buildings, and the ſtreets made at right angles to each other, without loſing an inch of ground. And though the capacity of an octagon is greater than that of this ſquare, yet the latter will contain as many buildings as the former.

A late *Engliſh* author goes upon quite contrary principles; for inſtead of making an octagon, whoſe exterior ſides are 180 toiſes each, he would make an enneagon, whoſe

whoſe exterior ſides are to be 170 toiſes only; whereby he pretends to gain great advantages. But as an enemy is obliged to carry his works no farther than three ſides, he will have leſs work to do in the attack of the enneagon than in the octagon; and as the angle of the polygon in the firſt exceeds by 5 degrees only that of the ſecond, the ſmall advantage ariſing therefrom, is by no means ſufficient to ballance the diſadvantage of leſſening the ſides; nor does it anſwer the expence of that baſtion which is added to the octagon. Beſides, we have proved, and it is allowed by the moſt able engineers, that the longer the exterior ſide of a fortification is, the ſtronger it will be, provided the lines of defence are not too long for muſket-ſhot; becauſe you can always place more men and guns in the works.

N. B. The truth of the foregoing propoſition and its corollaries is likewiſe confirmed by practice and experience; firſt, as to practice, if the plan of *Namur* be conſidered, it will be found, that at St. *Nicolas* gate, where the town is narroweſt, there are more works than in any other part; at *Cambray*, near the *Cantipers* and *Seille* gates, where the place is narrower than any where elſe, there

are horn-works; at *Lille*, near the gate of the ſick, is a caſtle in the curtain, a ravelin and counterguard before it, as likewiſe a horn-work before each baſtion: abundance of other examples might be given, which confirm the foregoing propoſition.

Experience has ſhewn likewiſe that large places moderately fortified, have made better defences in proportion, than ſmall ones of more works; for *Metz* in *Lorrain* was beſieged, without ſucceſs, by *Charles* the Vth emperor of *Germany* and king of *Spain*, although he had an army of 100,000 men, and the town was only fortified with a ſingle rampart, without baſtions and a dry ditch before it; *Lille* in *Flanders*, when beſieged by the allies, made a much better defence than any other place in that country; and laſtly, *Prague* in *Bohemia*, when beſieged by the *Auſtrians*, which has but a rampart with baſtions and a dry ditch, and yet the beſiegers were obliged to abandon it, without being in a condition to take it.

An ingenious gentleman has obſerved very judiciouſly, that an army of 30000 men may eaſily defeat 40000 men divided into two or three parts ſeparately, though not the whole together: the ſame reaſon

holds

holds good in fortification; for one place fortified moderately, and garrifoned with 30000 men, will make a better defence than three equally fortified, with a garrifon of 10000 men each.

It may be faid, that thefe places had ftrong garrifons, fkilful governors, and well provided with every thing neceffary for a good defence, and that the *Auftrians* before *Prague* were in want of artillery and ammunition to carry on the fiege, and that the fame place was taken a year before by the King of *Pruffia* and the *French*, in the firft affault. To this may be anfwered, that thefe places were only garrifoned in proportion to their extent, and *Lille* was obliged to furrender fooner than it would have done for want of powder and ammunition; and as to *Prague*, if the *Auftrians* had been well provided with neceffaries, they would have found it a difficult matter to force it, as may be judged by their beginning, fince what works and batteries they made were deftroyed by the befieged, and their cannon nailed up.

There are feveral other advantages in large fortified places, which cannot poffibly be had in fmall ones; as that the fick and wounded may be lodged in a quarter re-

mote

mote from the attack, where they are pretty ſecure from the beſiegers ſhells and cannon-ſhot; the ſeveral artificers neceſſary in a ſiege may do their buſineſs with leſs diſturbance, and thoſe troops which are not on duty may reſt and refreſh themſelves, whereby they are better able to do their duty; and laſtly, the powder may be lodged in ſeveral magazines at ſome diſtance from each other, ſo that it is not in the beſiegers power to deſtroy them, at leaſt not all; whereas it is a difficult matter to lodge powder in ſecure places in ſmall fortifications, the ſick and wounded are in a continual apprehenſion of being deſtroyed by the ſhells of the enemy, as happened in the ſiege of *Oſtend* laſt war, where there was not any one place ſecure from danger; and the troops not on duty, having no place to reſt themſelves in without fear, will never be able to act with that ſpirit as they would do otherwiſe.

It appears to me a vain imagination to think, that a fortification ever ſo ſtrong, with a ſmall garriſon, can reſiſt long a numerous army; for if their loſs is ever ſo inconſiderable in reſpect to that of the beſiegers, it muſt nevertheleſs prove a great detriment to them in the end; on the contrary, nothing

in

in my opinion, but a proportionable number of troops in a garrison, to that of the besieger's army, can make a proper defence according to the bigness of the place.

It may be said, that casemats or under-ground lodgements may be made for the troops to rest in and refresh themselves; but this cannot be done without great expence, and therefore the question is still, whether this expence is not better laid out in making a larger fortification, supposing the place is of sufficient importance to a nation; we except however those which are only made to defend a pass or a port, which might prove a temporary advantage to an enemy.

Having thus proved the foregoing proposition, and confirmed it by practice and experience, it will serve as a maxim or a general rule, on which irregular fortification is to be established; as likewise a standard, whereby the strength or weakness of those already fortified may be discovered.

As the situations of irregular places are so various, it is impossible either to enumerate them, or to give an example of each; therefore we shall endeavour to give such as are most common, and useful at the same time, by which the intelligent reader may be guided

guided in any other caſe that may occur to him.

If a ſituation is ſuch, as to make it impoſſible to reduce it into a regular form, it ſhould be brought to one as near as can be done; that is, if the polygon cannot be inſcribed in a circle, it ſhould be inſcribed in an ellipſis or oval; but as this inſcription is pretty difficult, we will give another method, which anſwers the ſame purpoſe, and is very eaſy in practice.

Pl.XXIV. Suppoſe a ſpot of ground to be reducible to the figure ACEG, draw BE, AF parallel to each other, ſo as the interval may be 180 or 200 toiſes, more or leſs, according as the nature of the ground will admit.

To theſe lines draw CH, DG perpendicular, and equally diſtant from the points B, E, ſo as their interval be equal to that of the lines BE, AF; this done, draw DC, GH parallel to AF, BE, and equally diſtant from them, and from their interſections C,D,H,G, with DG, CH, as centers, deſcribe arcs, with a radius equal to CD, or GH, ſo as to interſect the lines AF, BE, in A, B, E, F, and join the points A,B, and E,F; then will ABCDEFGH be an oblong octagon, ſo that one half will be ſimilar and equal to the other half.

Much

Much after the ſame manner may be deſcribed any other polygon; for example, in an exagon, inſtead of drawing the two lines CH, DG, there need be but one, in a decagon three, and in a dodecagon four.

If it ſhould ſo happen, as that all the ſides cannot be made equal without too much expence; then the ſides AB, EF, on the narroweſt part of the polygon, ſhould be the longeſt, if poſſible, on account of its being the weakeſt, as has been proved before.

It may ſometimes happen, that the figure cannot be made regular in any reſpect: in ſuch a caſe, the ſtrength of each ſide muſt be eſtimated according to the works a beſieger is obliged to make in the attack, and according to the obſtacles he meets with in his approaches.

If ſome parts of a place are commanded in front by a hill, the parapet muſt be raiſed 8 or 9 feet high, inſtead of ſix only, as is cuſtomary; if it is in the reverſe, then a traverſe muſt be made along the capital of a ſufficient height to cover the work; or in both caſes, cavaliers may be made nearly in the ſame form of the baſtion.

It

It may ſometimes happen, that there is an abſolute neceſſity of fortifying a re-entering angle, in which caſe the works muſt be conſtructed in ſuch a manner, that there may be no part but what can be flanked, or ſeen by ſome other part; in ſhort, all that art and knowledge can furniſh ſhould be uſed in irregular works; the weakeſt parts ſhould be made ſtrong by an addition of works; care muſt be taken that no part be commanded by a neighbouring hill, or riſing ground; and if that cannot be avoided, to raiſe traverſes or cavaliers; in general, particular care ſhould be taken to make every ſide equally ſtrong, and to be as frugal in the expence as poſſible, that the expence of building and the maintaining a garriſon, may not exceed the advantage ariſing from the fortifying of the place.

I have ſeen a project of a fortification which was to be built near a paſs, to occupy a hill which commands a neighbouring fortification * of a very odd figure, although made by an engineer of great repute; it

* *St. Philip*'s caſtle in *Minorca*. This hill commands the harbour as well as all the works of the caſtle, and yet it has been neglected hitherto; what uſe there can be made of it by the beſiegers will I am afraid, ſoon be known, but hope this will caution us another time.

was impoſſible to judge, from the diſpoſition of the works, for what intent the fortification was to be made.

When a place is to be fortified, it is of the greateſt importance to employ ſkilful engineers to form the project; and to have it afterwards examined with great care and judgment by others, in order to be ſatisfied that the figure is properly adapted to the ſituation and nature of the ground, and the number of works anſwerable to the importance of the place; but above all things, the expence of building, as likewiſe the number of troops for the garriſon, ſhould be well conſidered; for without that it is morally impoſſible that the place ſhould anſwer the end for which it is built.

Notwithſtanding that the foregoing principles are or ought to be quite obvious to any one that has the leaſt knowledge in fortification, yet many examples might be produced, wherein one would imagine that the projectors had not the leaſt regard to this precept, but on the contrary they ſeem to deſpiſe all the principles which are not of their own invention.

Con-

Conſtruction of an irregular place ſituated in an open country.

If the place to be fortified is an old town incloſed by a wall or rampart, as it moſt frequently happens, the engineer is to conſider well, all the different circumſtances of the figure, ſituation, and nature of the ground, to regulate his plan accordingly, ſo as to avoid the diſadvantages, and gain all the advantages poſſible ; he ſhould examine whether by cutting off ſome parts of the old wall or rampart, and taking in ſome ground, the place cannot be reduced into a regular figure, or nearly ſo ; for, if that can be done without increaſing the expence conſiderably, it ſhould by no means he omitted ; old towns have often towers placed from diſtance to diſtance, as *Douay*, *Tournay*, and many other places, which are generally made uſe of, and mended when it may be done ; if there is a rampart without baſtions or towers, it muſt be well conſidered, whether baſtions may not be added, or if it is not better to make only ſome outworks ; if the ditch about this rampart is not too wide and deep, it would be advantageous to make detached baſtions,

baſtions, otherwiſe ravelins and counterguards muſt be conſtructed; ſpecial care muſt be taken, to make all the ſides of the polygon as nearly equal as poſſible, and that the length of the lines of defence do not exceed the reach of muſket-ſhot; but if that cannot be done, thoſe ſides which are on the narroweſt part ſhould be made the longeſt.

If it ſhould happen, that ſome of the ſides are inacceſſible, or of very difficult approach, either on account of ſome precipice, marſhy ground or inundation, they may be made much longer than the others, which are of eaſy acceſs, and the flanks need not be ſo large as the reſt; by doing ſo, there will be ſome expences ſaved, which may be uſed in making the other ſides ſtronger, by adding more outworks.

There are few ſituations, but what are more advantageous in ſome parts than in others; it is therefore the buſineſs of an engineer to diſtinguiſh them, and to render thoſe ſides ſtrong by art, which are not ſo by nature.

If the ſituation is low and watery, lunettes or tenaillons, and ſuch other ſmall outworks, ſhould be conſtructed, becauſe they are not of any great expence, and may

make a very good defence; but if one ſide of the place is only low, and running water is to be had, a ſecond ditch and covert-way with lunettes, may be made, by obſerving, that if the firſt glacis is made to ſlope, ſo as to become even with the level of the water in the ſecond ditch; or if the water can be ſwelled, by means of dykes or ſluices, ſo as to overflow the beſt part of the firſt glacis, it ſhould be done; for by ſo doing, theſe works will be able to make a very good defence, ſince the beſiegers will find it a difficult matter to lodge themſelves upon this glacis, which cannot be done but within a few toiſes of the firſt covert-way, where the beſieged are ready to receive them, and to deſtroy their works with great advantage; whereas the enemy cannot ſupport their workmen but from the ſecond covert-way, which is too far off to be of any great ſervice to them.

But if the ſituation is of a dry nature, without any water about it, caponiers ſhould be made in the great ditch, from the curtains to the ravelin, and batteries raiſed in the entrance of the ditch before the ravelin, whoſe parapet muſt ſlope off into a glacis, ſo as to afford no cover for the enemy

behind them; arrows and detached redoubts are likewiſe very proper to be uſed in ſuch a caſe, and ſometimes horn or crown-works, if it ſhould be thought convenient; but theſe works ſhould never be conſtructed, without an abſolute neceſſity, either to occupy a ſpot of ground which might be advantageous to the enemy, or to cover ſome gate or entrance into the town; for they are of great expence, and their defence ſeems not to be anſwerable to it.

Moſt of the places in *Flanders* are fortified with horn-works, ſuch as *Ipres*, *Tournay*, *Lille*, and others; *Lille* has four, *Ipres* as many, two of which are injudiciouſly placed near one another. I am ſurpriſed that M. *Vauban*, who undoubtedly was in all reſpects the beſt engineer, and who fortified many places with ſo much judgment, ſhould have been ſo fond of making theſe kind of works, which are, in my opinion, the worſt of all his fortifications, in the manner they have been conſtructed in the above-mentioned places; it muſt certainly have been before he had acquired that knowledge, for which he is ſo much eſteemed; and what renders this conjecture probable is, that he has but ſeldom made uſe of

them, in the conſtruction of thoſe places which he fortified in his latter time; and where he made any, it was always to cover a gate or entrance into the town.

If the place to be fortified is new, and the ſituation will not admit of a regular conſtruction; particular care muſt be taken, in chuſing ſuch a ſpot of ground as is moſt advantageous, and leaſt liable to any diſadvantages, either in the building or in the maintaining of it; all hills or riſing grounds ſhould be avoided, which might command any part of the works, and marſhy grounds, becauſe ſuch ſituations are unwholeſome; or lakes and ſtanding waters for the ſame reaſon, excepting a lake is, or may be made navigable; good water ſhould be had either within the place or near it, for it is abſolutely neceſſary for men and cattle; the air ſhould be wholeſome, otherwiſe the continual ſickneſs that may reign in ſuch a place might prevent people to come and live in it, and the garriſon would not be in a condition to defend themſelves as they ought to do; in ſhort, all the different circumſtances attending ſuch an undertaking ſhould be maturely conſidered, before a reſolution is taken to fortify any place.

When

When a ſituation is pitched upon, the next thing to be conſidered, is the bigneſs of the town and the number of its outworks, which muſt abſolutely depend upon the conſequence ſuch a place is of to a nation; if it is only to guard a paſs, or entrance into a country, it need not to be ſo large; but if it is to be a place either to promote or to protect trade, it ſhould be large and commodious: the ſtreets ſhould be wide, and the buildings regular and convenient; as to what regards the fortification, its conſtruction ſhould depend on the nature of the ſituation, and the number of works, on the funds, or expence a prince or a nation will be at; which however ought to be according to the benefit ariſing from ſuch a place. For as ſuch undertakings are of very great expence, an engineer cannot be too ſparing in his works; on the contrary, the greateſt œcconomy ſhould be uſed, both in regard to the number of works, and to their conſtruction. The body of the place may have *revetements quite up to the top, or only in part, and the reſt turfed; but as to the outworks, they ſhould

* Revetements are chiefly made to prevent a place from being ſurpriſed; outworks do not want to be made ſo, the taking them by ſurpriſe is of no great conſequence, except in a ſiege, when other cautions are uſed to prevent it.

have half revetements, or they may be made with turf only; as being not so necessary to prevent the place from being surprised, and may nevertheless make a good defence.

The plate XXIV, is the plan of an octagon, one half of which is similar and equal to the other half; it being supposed that the situation would not admit of a fortification quite regular; the exterior sides are each 180 toises, and the works are constructed according to our method; but because the sides AB, EF are weaker than the rest, as has been proved before, we have added tenailles, redoubts in the ravelins, and lunettes, to render them nearly equal in strength with the others; and if counter-guards were made before the bastions A and B, it would effectually secure that front. Instead of lunettes, any other works may be made, as it may be thought convenient, and according to the nature of the ground. If it should be judged necessary to add other outworks to the ravelins all round the place, care must be taken to add likewise more to the fronts AB, EF, in order to render the advantages and disadvantages of attacking on either side equal.

Conſtruction of an irregular place ſituated on a hill, or rock.

In the conſtruction of ſuch places, care muſt be taken that no neighbouring hill commands any part of the works, the town ſhould always be built on the higheſt part; but if it ſhould be thought more convenient to place it lower, then the upper part muſt be fortified with a fort; the ſituation ſhould be made level as near as poſſible, by removing the earth from ſome places to fill up others; and if that cannot well be levelled without extraordinary expence, works muſt be made on the higheſt part, ſo as to command and protect the lower; the works ought to occupy all the upper part of the hill, but if it ſhould be too extenſive to be all incloſed, or ſo irregular as not to be fortified without great inconveniency, the parts which fall without ſhould be fortified with ſome detached works, and a communication with the place muſt be made either above or underground. There ſhould be no cavity or hollow roads within cannon-ſhot round about the place, where the enemy might be able to approach under cover; if

there ſhould happen to be a ſpring, near the top of the hill, it ſhould be incloſed in the fortification, or if that cannot be done, by ſome work or other; for there is nothing more neceſſary, and at the ſame time ſcarcer in ſuch ſituations, than water, for which reaſon there cannot be too much care taken in providing it; ſeveral ciſterns are to be made to receive the rain-water, and to preſerve it; wells ſhould be dug likewiſe, though ever ſo deep, the water of which will ſerve for common uſe.

Places built on hills or rocks, ſhould never be large, for their uſe is generally to guard paſſes or inlets into a country, and are ſeldom uſeful in traffick, and it is a difficult matter to provide for a large garriſon in ſuch ſituations; neither ſhould any ſuch place be built without ſome very material reaſons; but when it is abſolutely neceſſary, great care and precautions ſhould be taken to render the works as perfect as the ſituation will admit of, and at the ſame time to be as frugal in the expence as poſſible.

Con-

Construction of irregular fortifications, situated near rivers, lakes, or the sea.

As the intent of building these kind of places, is chiefly to facilitate and protect trade, it is of much more importance than any other kind, especially in maritime countries, where the principal strength and power depends on it: for which reason, we shall treat of it more largely than of any other part.

The first thing to be considered is their situations, which ought to be such as to afford a good harbour for shipping, of a safe and easy entrance in stormy weather; but as it is hardly possible to find any, where ships may go in and lie secure, with all winds, care should be taken to make them safe to enter with those winds which are most dangerous; but it is not sufficient that the harbour is safe against stormy weather, they should likewise be so against an enemy, both by land and water; for it often happens that ships are destroyed where it was imagined they were secure, which is of too great a consequence not to be provided against; for which reason, forts or batteries must be built in

in the moſt convenient places, to prevent the enemy's ſhips from coming too near, ſo as to be able to cannonade thoſe in the harbour, or fling ſhells amongſt them; and if there is any danger of an enemy's approach by land, high ramparts and edifices muſt be built, ſo as to cover them.

When a river is pretty large, and it is not convenient for making a harbour without great expence, the ſhips may ride along the ſhore, which, for that reaſon, muſt be made acceſſible for ſhips of burthen; this may be done by advancing the quay into the river, if the water is too ſhallow, or by digging the river ſufficiently deep for that purpoſe.

And to prevent any enemy from coming up the river, forts muſt be built on both ſides, eſpecially when there is any turnings or windings. *Antwerp* is ſuch a place, for the *Scheld* is ſufficiently deep to carry ſhips of great burthen, which may come quite near the town-wall; and ſeveral forts are built below it on both ſides, ſo that it would not be an eaſy matter for an enemy to come up the river.

When the river is but ſmall, ſo that no ſhips of burthen can come through it; it is ſufficient to make it run through ſome

of

of the works, where proper landing places are contrived, from whence the goods may be carried into the place; as at *Sarrelouis*, where a horn-work is built beyond the *Sarre*, in the gorge of which the goods are landed.

If the breadth of the river does not exceed 200 yards, it commonly paſſes through the middle of the town, and proper quays are made on each ſide; in ſuch a caſe, the fortification is ſo contrived, as that the river paſſes through the curtain, in order to have a baſtion on each ſide to defend the coming in and going out.

When M. *Vauban* fortified near rivers, he made always the exterior ſide near the water much longer than any of the others; ſuch as *Hunningen* on the *Rhine*, and *Sarrelouis* on the *Sarre*; but for what reaſon he fortified theſe places in that manner, has not been told by any author I know of; for thoſe who beſtow moſt praiſes on him, are quite ſilent in this reſpect, although theſe works ſhew better, in my opinion, his great ſkill in fortification, than many others for which he is generally eſteemed; it is true, authors treat in general ſo ſuperficially of irregular fortification, as would incline one

to

to believe that they either knew not the importance of the ſubject, or elſe imagined it was impoſſible to reduce it under general rules or maxims, whereby its perfections and imperfections might be diſcovered.

But it is plain, from what has been demonſtrated before, that the ſides which terminate at the river, are the weakeſt; becauſe the beſiegers trenches being ſecured by the river, they may draw moſt of their troops off, and act therefore with more vigour and ſtrength on the other ſide: beſides, as the ſtrength of a ſide increaſes in proportion as the angle of the polygon is greater, by making the ſide next the river longer, the angles at its extremities become wider, and conſequently the adjacent ſides ſtronger.

There are other advantages, beſides theſe mentioned already, which ariſe from the lengthening that ſide; for if the river is pretty deep, ſo as not to be fordable, that ſide is not liable to be attacked; and by increaſing its length, the capacity of the place increaſes much more in proportion to the expence, than if more ſides were made; the center of the place will be likewiſe nearer the river, which makes it more convenient for

for tranſporting the goods from the water-ſide to any part of the town.

To illuſtrate this method of M. *Vauban*'s, we ſhall give the plan of *Hunningen*; this place was built for the ſake of having a bridge over the *Rhine*, for which reaſon he made it only a pentagon; the ſide AB next to the river is 200 toiſes, and each of the others but 180; the body of the place, as likewiſe all the outworks, are conſtructed according to his firſt method, by obſerving that the perpendicular to the ſide A B is only 25 toiſes, according to the table given at the beginning of his firſt method, and the capital of the ravelin before that front 28; whereas thoſe of the others are 50. Pl. XXV.

About the ſpace *a b c*, which lies before the front AB; is a ſtone wall, and the paſſages *x*, *x* are ſhut up with ſluices, to retain the water in the ditches in dry ſeaſons, and to prevent an enemy from deſtroying the ſluice near the point c, whereby the water would run out and leave the ditches dry; the redoubt y was built in the little iſland hard by, in order to cover that ſluice; without this precaution the place might be inſulted from the river ſide, where the water is ſhallow in dry ſeaſons.

The

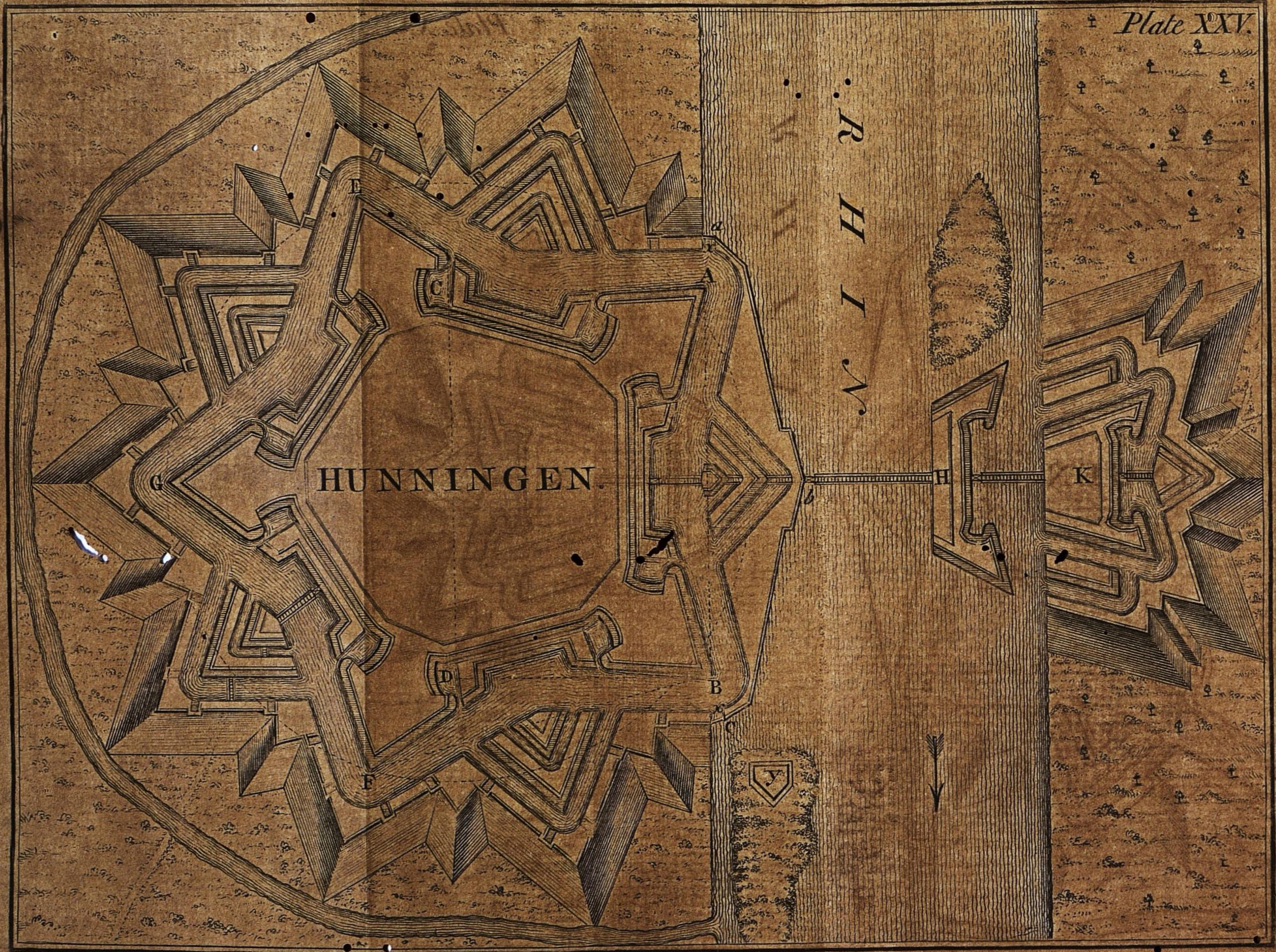
The horn-work K beyond the *Rhine* was built to cover the bridge, but as this work cannot be well defended 'crofs the river, the horn-work H was made to fupport the other. There are likewife horn-works before the baftions E, F, and a little work before the baftion G, called *Paté*, which we have omitted for want of room.

There feems to be nothing in this fortification but what is well contrived, and here certainly the author has fhewn his fkill; the only things which appear to me fuperfluous, are the horn-works placed before the baftions, E, F, and the *paté* before the baftion G; for I think there are too many works confidering the fmallnefs of the place; and as the horn-works were chiefly made to fecure a fafe retreat over the wet ditch beyond the glacis, as I fuppofe, in cafe of a fally, a couple of detached redoubts might as well have anfwered the purpofe.

Some of my readers will undoubtedly be furprifed to read my encomium on this fortification, whilft M. *Coehorn* looked upon it as an ill-contrived piece of work; but if they will be pleafed to confider that he was mifled by a falfe or incorrect plan, for that very thing he faid was wanting, meaning the

work

Plate XXV.



Müller delin.

J. Mynde sc.

work *a b c*, which retains the water in the ditches, was actually executed by M. *Vauban*, as this plan ſhews.

Before we finiſh the deſcription of this plan, we ſhall ſhew how to find the long ſide A B, as being uſeful in the following work.

After having inſcribed the two ſides G E, GF, in a circle, draw the diameter CD, ſo as to be equally diſtant from the line joining the points E, F, that is, parallel to it; on this diameter ſet off 100 toiſes on each ſide of the center, from theſe points draw two indefinite perpendiculars to the diameter; then if from the points E, F, as centers, two arcs are deſcribed with a radius of 180 toiſes, their interſections A and B, with the ſaid perpendiculars, will determine the long ſide AB, as likewiſe the other two FB and EA. In like manner may be found the long or ſhort ſide of any polygon whatſoever.

When a place near a river is to be fortified, for the ſafety of commerce, particular care ſhould be taken in leaving a good ſpace between the houſes and the water-ſide, to have a key or landing-place for goods brought by water; it ſhould alſo be contrived to have proper places for ſhips and boats to lie ſecure

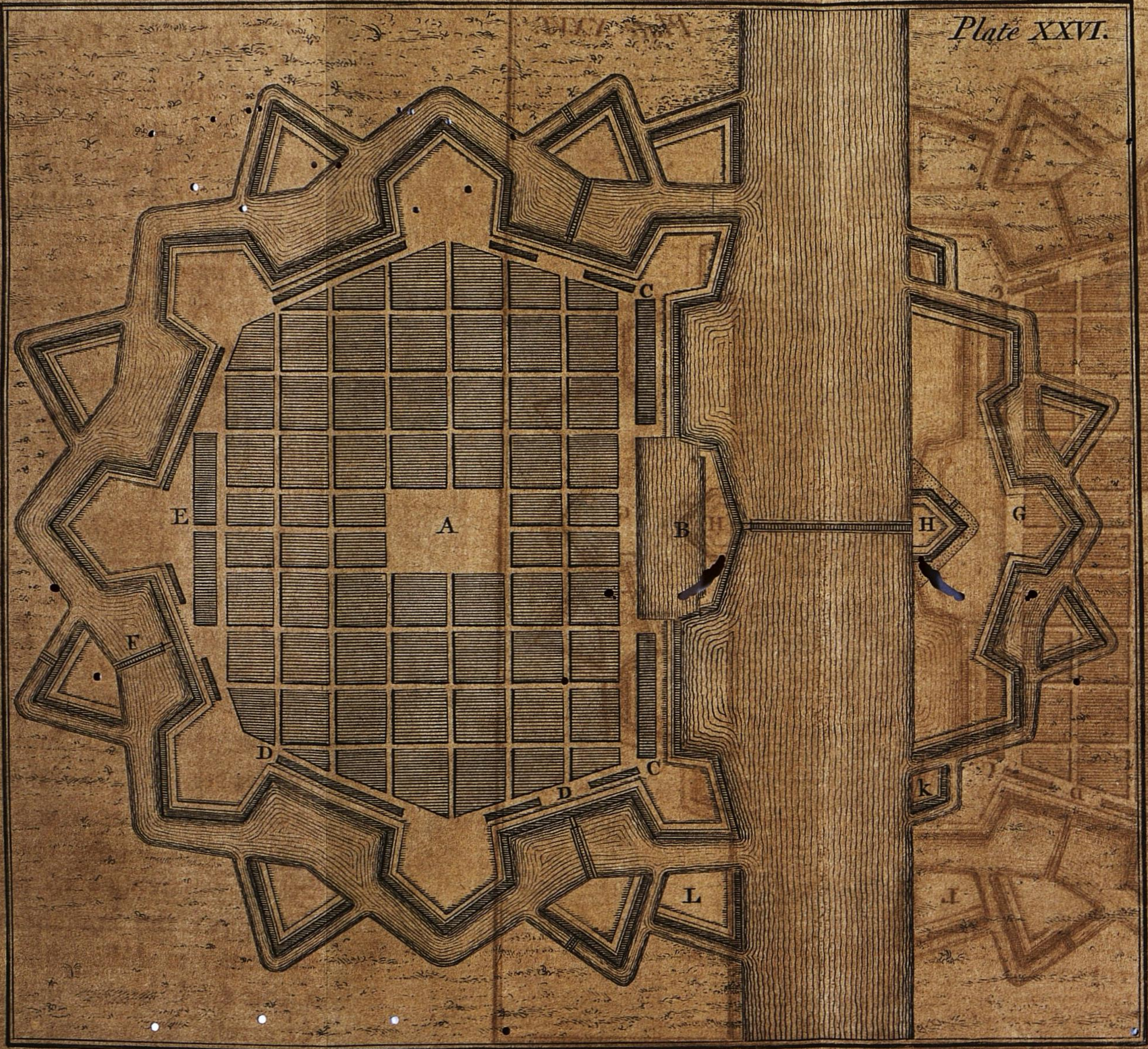
ſecure in ſtormy weather, and in time of a ſiege; and as water-carriage is very advantageous for tranſporting goods from one place to another, as likewiſe for bringing the neceſſary materials, not only for building the fortification, but alſo the place itſelf, the expences will be leſſened conſiderably, when this convenience can be had; for which reaſon places ſhould never be built any where elſe but near rivers, lakes, or near the ſea; excepting in extraordinary caſes, where it cannot be avoided.

For the better underſtanding this important part of fortification, we ſhall give ſome examples of various kinds, from which the reader may gather the manner of fortifying others of the ſame nature.

Example I.

Pl.XXVI. We ſhall ſuppoſe a river of 100 toiſes or more broad, and ſuch as is always navigable, at leaſt for ſmall veſſels or boats, and the ſituation to be ſuch as to admit of a regular fortification; the body of the place is a regular octagon, and the flat ſide next to the river cuts off a fourth part from the circle, and is lengthened ſo as to be 360 toiſes; the perpendiculars are 25 toiſes only on this ſide, and all the others 30; the faces 50, and the flanks

Plate XXVI.



Müller delin. J. Mynde sc.

are found according to our method; the great ditch is 16 toiſes, and the ravelins are conſtructed as uſual; the lunettes L near the river have one of their faces perpendicular to the middle of thoſe of the adjacent ravelins, and the others are parallel to the flat ſide; their ditch is 12 toiſes. Within the flat baſtion is a baſon B, to receive ſhips, 40 toiſes broad, and its length is terminated by perpendicular lines drawn from the extremities on the adjacent curtains, and a paſſage is made in each flank of 10 toiſes, for the ſhips going in and out; theſe paſſages are ſhut up with ſluices, with a kind of a paſſage over them, in order to have a free communication with the flat baſtion, and from thence over the bridge into the fort G, on the other ſide of the river.

This fort is conſtructed in the following manner; from the ſaliant angle of the flat baſtion, as center, deſcribe an arc with a radius of 200 toiſes; on which ſet off two chords of 120 toiſes each, for the exterior ſides, the perpendiculars to which are 20 and the faces 35; the branches of this fort are perpendicular to the oppoſite faces of the baſtion; the ditch before this work is 12, that of the ravelin 8; and the ravelin as well as the flanks are conſtructed according to our

 method.

method. The ſemi-gorges of the lunettes k are 20 toiſes each; and the faces are, the one perpendicular, and the other parallel to the branches of the fort; they ſerve to cover the entrance into the baſon B, which might otherwiſe be ſeen from thence; the ditch before theſe lunettes is 8 toiſes.

The gorge of the redoubt H is 40 toiſes, the flanks 10, the faces 30, and the ditch before it 6; this work ſerves for ſecuring the retreat when the fort G is taken; and whilſt the enemy is endeavouring to get maſters of it, the troops may retire in the dark over the bridge into the town.

The market-place A is about 70 toiſes one way, and 50 the other; all the ſtreets 6, which is rather too much for the bye ones; our deſign is not ſo much to give the particular dimenſions of them, as to ſhew that they ſhould be perpendicular to the river, and croſs each other at right angles; reſerving the reſt for the practical part of fortification.

The buildings C, C, are deſigned for naval ſtore-houſes, E a ſtore-houſe for land ſervice, D for barracks, and F are the bridges near the gates of the town.

We have given the conſtruction of the body of the place and ravelins only, without

deter-

determining the reſt of the outworks, whoſe number and capacities depend on the importance of the place. It ought to be remembered, that it muſt be better fortified near the river than any where elſe, it being the weakeſt part, as has been proved before.

If the ſituation does not admit of a regular fortification, then it muſt be conſtructed in ſuch a manner, as to approach as near to it as can well be done, without being at an exceſſive expence; and if there ſhould be a hill, or riſing-ground within cannon-ſhot, which can ſee into ſome of the works, it muſt either be fortified, or cavaliers are to be made in the oppoſite baſtions.

It may ſometimes happen, that the river forms a natural baſon for ſhipping, or they may be made ſerviceable by a little work; ſuch an advantage is by no means to be neglected, a ſkilful engineer will know how to uſe all the advantages which the nature of the ground affords, ſo as to be ſaving in the expences, and to make the place in the moſt convenient manner.

The landing places may be made in the great ditch, near the curtains next to the river, if it is thought proper; in ſuch a caſe, part of thoſe curtains may be left open, in order

to have a quay, and round theſe kind of harbours, ſome works ſhould be conſtructed to ſecure the ſhips in time of war.

Example II.

Plate XXVII. It may ſometimes be judged more convenient to build the place on both ſides the river, than on one only; in ſuch a caſe, the river ſhould always paſs through the curtains, in order to have a flank on each ſide, to defend its entrance and coming out; if the river is not very large, the curtains may be built acroſs the river upon arches, which may be made to ſhut in the night, or in time of a ſiege with portcullices; and the middle arch may be made wider than the reſt, and left open at top, with a draw-bridge over it, for ſhips to ſail through. But if the river is above 100 toiſes large, the building curtains acroſs would be too expenſive; in ſuch a caſe a fort, ſuch as B, may be made in the middle of it; from whence chains and booms may be laid to the ſhore in the night, and in time of danger.

The conſtruction of the body of the place may be as follows.

Suppoſing the ſituation to be ſuch as to admit of a regular conſtruction; each ſide is

2 a part

Plate XXVII.

a part of a regular octagon, inscribed in a circle, whose centers O are within 10 toises from the river; the body of the place is constructed according to our method, and the ditch is 16 toises; as to the rest of the works, their number and bigness may be made in what manner it is thought proper, and according to the importance of the place.

The streets are to be perpendicular to the river, and to cross each other at right angles; and for a greater conveniency of transporting goods from the ships to the market, a market-place may be made on each side near the river. We have added lunettes, such as A, to defend the entrance and going out of the river, one of the faces of which is perpendicular to the opposite faces of the bastions within 25 toises of the shoulders; this face is about 60 toises long, and the others are so drawn, as to be perpendicular to each other.

As the enemy will hardly attack the place near the river, because an attack made on one side only, is liable to be enfiladed from the other by the garrison; and when it is made on both sides, the troops are divided, and not in a condition to support each other; it is not therefore necessary to make the fortification stronger there; on the contrary, as

it will probably be attacked on the ſide quite oppoſite to the river, ſome more works ſhould be made in this place.

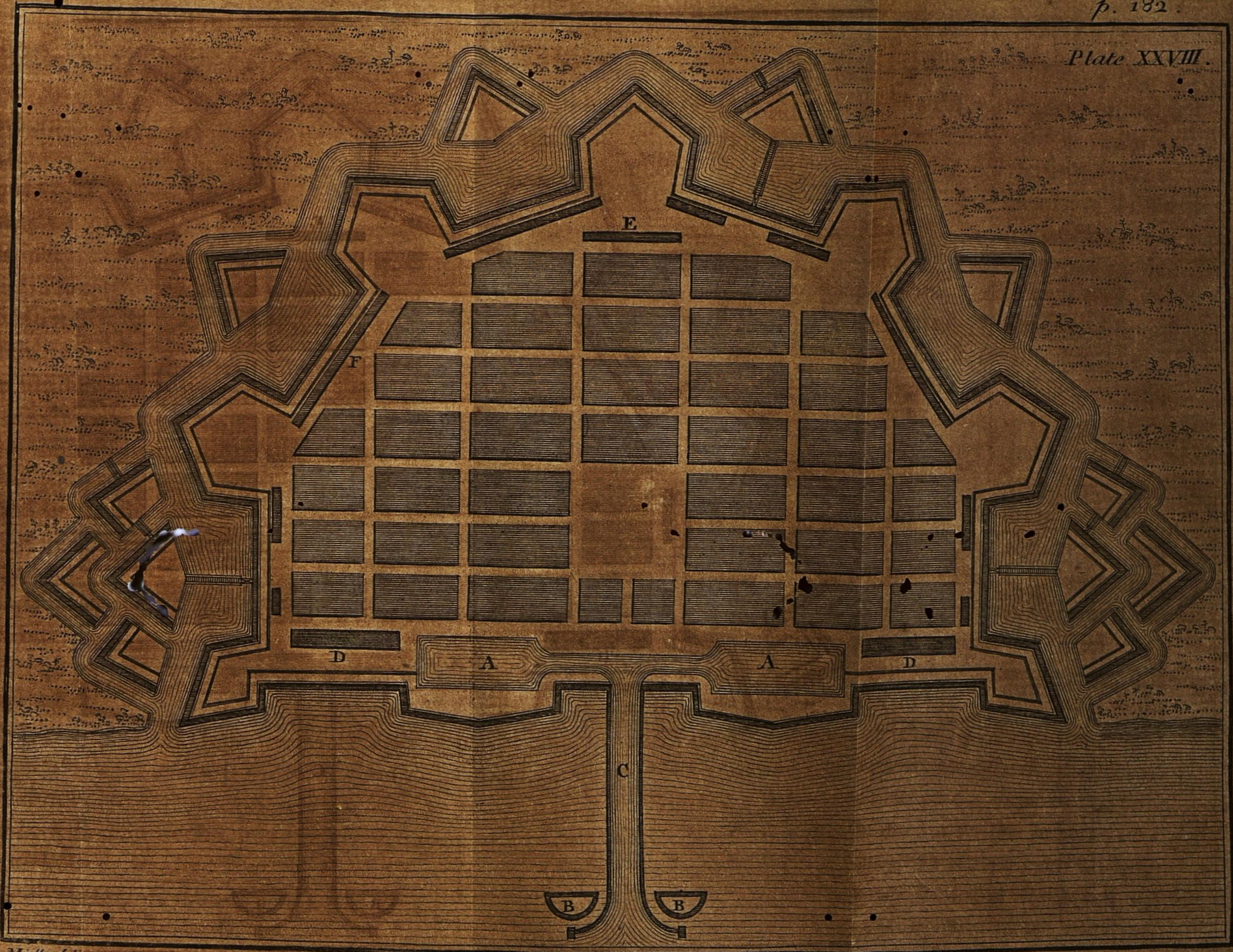
Notwithſtanding the booms and chains, which are to be laid acroſs the river, in the night and in time of danger, the enemy may find an opportunity to force his way through, whereby the place might eaſily be taken. To prevent which a wall of 8 or 10 feet high ſhould be built along the river, with iron gates oppoſite to the ſtreets, ſo as to be locked up at night.

EXAMPLE III.

Places built near the ſea are of the greateſt importance to a nation on account of trade; ſo they require likewiſe the greateſt care in the chuſing their ſituations, in ſuch a manner as to be of the leaſt expence in building, and the moſt convenient for ſhipping. We ſhall ſhew how ſuch a place may be fortified, when the ſituation is plain and even, and where there is no harbour formed by nature.

Plate XXVIII. This plan is a part of a regular decagon, four ſides of which are cut off for the flat ſide next to the ſea, the perpendiculars to which are but 15 toiſes; all the reſt of the works are conſtructed as uſual; as the place is weakeſt

Plate XXVIII.



Muller delin.

J. Mynde sculp.

weakeſt near the ſhore, we have added lunettes with bonnets, to make it nearly equal in ſtrength there with the reſt of the ſides; we have added no outworks beſides ravelins and lunettes near the waterſides, becauſe their number and capacities depend on the importance of the place.

The baſons or harbours A, A, are 30 toiſes broad and 80 long, and the entrance into them 10; this we imagine might be ſufficient for ſhips going in and out: however, it may be made more or leſs, according as it will be thought convenient; our deſign being rather to ſhew the figure, and in what manner it may be done in ſome caſes, than to pretend to give the exact dimenſions, which ought to be determined by experience, or according to the nature of the ſituation.

The channel or road C, leading into the baſons A, A, is 18 toiſes broad, and muſt be as long as the ſhallow water goes; B, B, are two ſemi-circular forts to defend the entrance into the harbour, which being made of that figure, are better for defence on every ſide. If theſe forts ſhould not be thought ſufficient, one or two more may be made between theſe and the place, or on ſome flats or ſands where the ſhips cannot come too near.

The buildings D, C, are naval ſtore-houſes E a ſtore-houſe for land ſervice, and F the barracks.

The ſtreets and other buildings are to be made nearly in the manner expreſſed here in the plan; but the market-place might be made quite open to the ſea, if it is thought proper.

We ſuppoſed here in this plan, that there is no harbour formed by nature, for which reaſon an artificial one is made; but if there be any bay, creek, or large baſon, formed by the ſea, or a river, it ought to be uſed and enlarged, if neceſſary, and ſometimes moles are made to form a harbour, as at *Gibraltar*; by which a great deal of labour and expences are ſaved.

If a place is to be fortified in an iſland formed by the ſea, and there is a navigable river, then the propereſt ſituation will be at its entrance, if the river is but ſmall; or a little way up in the land, if it is pretty large, ſo as not to be in danger of a bombardment from the ſea; but it muſt be obſerved, that here, and in all places of this kind, the conveniency for making a good harbour muſt chiefly be conſulted, whoſe entrance ſhould always be defended by two or more forts or batteries, placed on both ſides of it.

It will alſo be proper to take particular notice, that if an enemy may land any where thereabouts, the forts muſt be built ſo as to be every where equally ſtrong, in order to be in a condition to reſiſt which way ſoever they may make their attack; the want of this conſideration has often proved of dangerous conſequence, becauſe if theſe forts or batteries may be ſurpriſed, the harbour will lie open to the enemy, who therefore may enter without any farther danger, deſtroy the ſhips, and take the town. It is by no means ſufficient to raiſe batteries in ſuch places as command the entrance of a harbour, without conſidering likewiſe whether their conſtruction is ſuch as to anſwer the purpoſe for which they are built; they will otherwiſe be of very little uſe in the defence of the place: if there ſhould be but one or two ſuch places where an enemy may land, they ought to be fortified with ſome ſmall works; but if there are ſeveral, it is much better to build two good forts, one on each ſide of the harbour, near ſome ſhallow water, ſo that the ſhips may not approach too near, to prevent their being demoliſhed by them.

If a ſmall iſland formed by a river is to be fortified, care muſt be taken to occupy the

the whole iſland if poſſible, in order that the works of the fortification may defend every part of the firm land, whereby the enemy will not be able to land any where without great danger and difficulty; but if the iſland ſhould be ſo large, that the whole cannot be conveniently fortified, and ſome parts are acceſſible and others not, the place ſhould then be built in the moſt acceſſible part, and the others, if not too many, may be fortified with ſmall forts or batteries.

If there is any lake of ſome length, or which diſcharges its waters into a navigable river, a place built near it will be very convenient for trade; although a lake has no communication with the ſea, or is not navigable, at leaſt for large ſhips, yet it may be very uſeful for trading with the country round about; the bigneſs and ſtrength of ſuch a place muſt be according to its importance.

We have thus explained, in a few words, the manner of fortifying places ſituated near navigable rivers, lakes, or the ſea, which is far from being ſufficient to give a complete notion of the ſubject; it would require a whole volume to enumerate all the different circumſtances that may poſſibly happen, either in reſpect to the various ſituations formed

by

by nature, the conveniencies required to ſave expences, or their importance with regard to traffick; for all theſe conſiderations are to be maturely conſidered and well weighed at leiſure, before an undertaking of this importance is put in execution.

It would be a help to the reader, if a great many plans of places already executed were collected; for by examining them with all the attention and care that is poſſible, and not omitting the leaſt circumſtances, ariſing from their different ſituations or nature of the ground; as likewiſe from the importance they are of either to protect or increaſe trade and then taking notice for what reaſons works are made in ſuch a manner in one caſe, and different in another, a right notion might be formed of the ſubject, ſo as to be able to proceed in any other caſe of the like nature. But as this would ſwell the work too much, and draw it into a greater length than is agreeable to our purpoſe, we ſhall finiſh this part with explaining the ſituation of a few places already built, to ſupply, in ſome meaſure, what is wanting to complete the ſubject.

At *Dunkirk* is a bank of ſand before the entrance into the harbour, nearly parallel to the ſhore, which is an admirable defence againſt

'against any bombardment; for when ſhips lie without it, they are too far from the place to do it any damage; and if they ſhould venture to go between this bank and the ſhore, there is a fort built ſo nigh, which would deſtroy them, as not having ſufficient room for working a ſhip, ſo as to turn about; the channel leading into the harbour is pretty long, and defended by two forts on one ſide, and three on the other, which makes it impracticable for an enemy to paſs through it. Another great convenience this port has, is, that there are three rivers, coming from the inland country, which run into the harbour; at their entrances are ſluices, which are ſhut up at high water, and opened at low, which carry out the mud and ſand brought in by the ſea, and thereby prevent the harbour from being choaked up.

Whenever a ſituation is to be found, that has theſe advantages, it ſhould not be neglected, ſince it ſaves great expences in keeping the harbour always clear, and renders an attack by ſea impracticable.

Oſtend lies cloſe to the ſea, and the road leading into the harbour, which lies oppoſite to the ſea, paſſes by one ſide of it; but as the entrance is very difficult, and no wind but a north-

north-weſt one will permit any ſhips to enter, and the town being liable to a bombardment, ſuch a ſituation as this is not to be uſed, excepting other reaſons occur for fortifying it; this place has one advantage, that it cannot be attacked by land but on one ſide only, which is along the ſhore, becauſe all the other ſides may be ſurrounded with water in the time of a ſiege, and therefore the acceſſible ſide may be made ſo ſtrong, as to make it a difficult matter to take it that way.

This notion has been found to be erroneous in the laſt ſiege; for the *French* found means to place two batteries on the other ſide of the channel that leads into the harbour, the one fired into the entrance of the channel, and the other directly into the harbour. This laſt battery being ſeen, from the face of the oppoſite baſtion, ſomewhat oblique, where 12 eighteen pounders were mounted, which would ſoon have ſilenced this battery, had the *French* not prevented it by tracing another epaulement parallel to, and about 20 yards behind the firſt, and making the embraſures of the laſt in a line with thoſe in the firſt, by which they could fire into the harbour, and they were covered by the firſt epaulement againſt the guns of the place.

Antwerp

Antwerp lies near the *Scheld*, and has no other harbour than the river itſelf, which is large and navagable for ſhips of great burthen. A citadel is built above the town, to defend it againſt an enemy coming by land, and below are ſeveral forts on both ſides the river, to prevent an enemy from approaching it by water; this place is ſo happily ſituated, that it was formerly the principal trading place of all *Flanders* and adjacent countries; but afterwards, when the *Dutch* had ſhaken off the yoke of the *Spaniards*, and the beſt part of *Flanders* was ſubjected to the houſe of *Auſtria*, the *Dutch* prohibited all the trade of this place, and transferred it to their own dominions.

By what has been ſaid with reſpect to this place, the reader may eaſily perceive the great advantages it has; and that few ſituations deſerve ſo much notice to be taken of them as this.

Boulogne is ſituated near a creek going pretty far up the land, at the entrance of which is a bar difficult to paſs without a good guide; and on one ſide is a high hill which commands it entirely, ſo that the place is ſecure againſt any attack by ſea; for which reaſon, ſuch a ſituation is not to be neglected.

Dieppe is another place ſituated near the ſea; the channel or entrance into harbour is guarded by two piers or moles, which harbour is nearly perpendicular to the ſea, with a turning near the channel.

The channel and harbour of this place ſeem to be very convenient, and as they are chiefly formed by nature, the expence of making them muſt be inconſiderable; but the places itſelf is ſituated ſo near the ſea, as to make it liable to a bombardment, ſuch a ſituation ſhould therefore be avoided, excepting forts can be made ſo as to prevent the approach of an enemy's fleet.

The laſt ſea-port we ſhall mention is the famous one of *Toulon*, ſituated in the *Mediterranean*; the entrance into the bay or road is large and ſpacious, covered by a neck of land, and defended by three caſtles, two forts and ſix batteries; the road is ſo large, that a whole fleet may ride in it; adjoining to the town are incloſed two large harbours by piers or moles, the one for the king's ſhips, and the other for merchant men; the firſt is much larger than the ſecond, and its entrance is made in the form of a V open at bottom, by which the ſhips are carried in gradually, without danger of running againſt the piers.

To

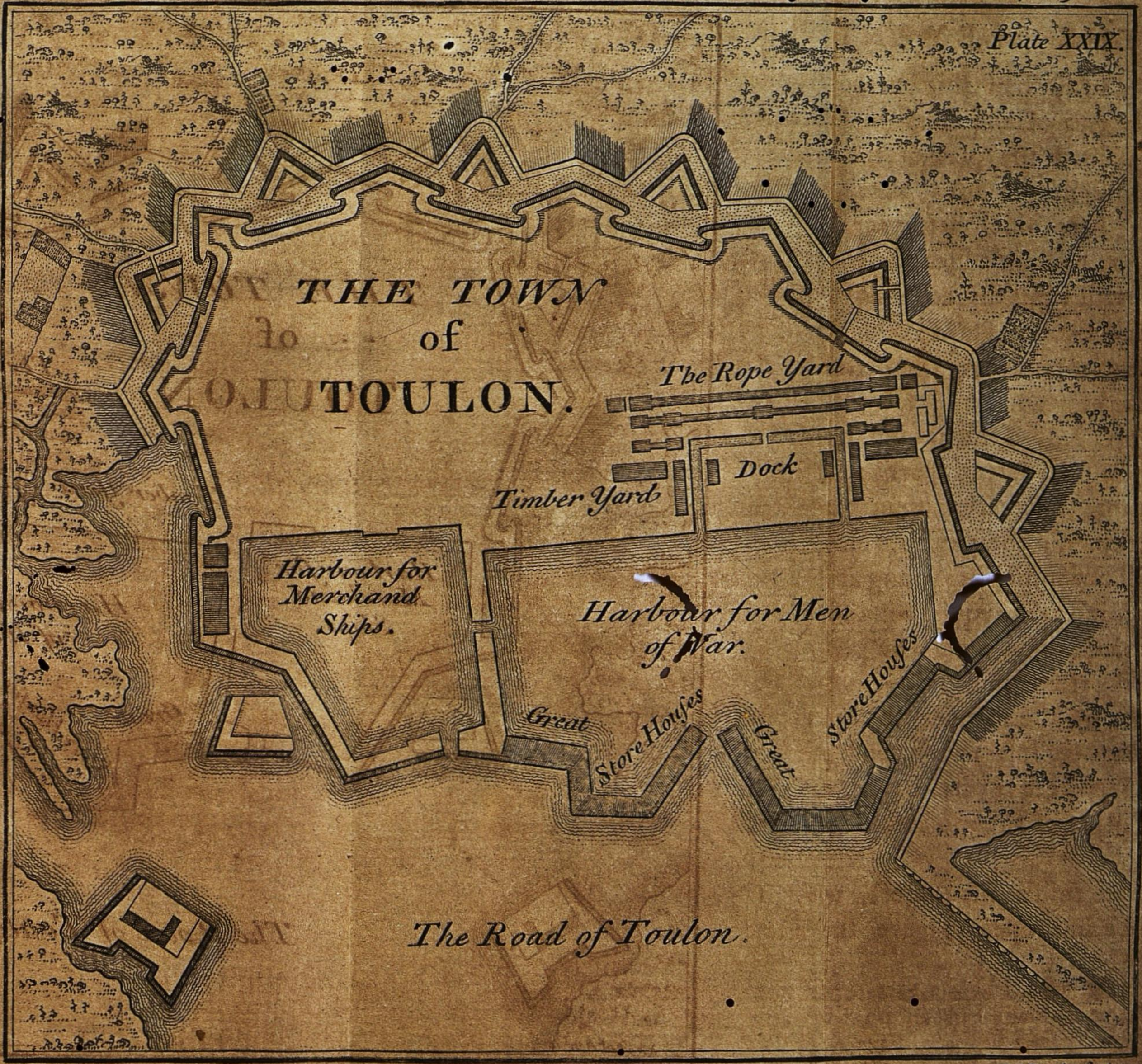
Pl. XXIX. To give an idea of this* harbour, which is certainly one of the fineſt in *Europe*, we have repreſented the plan of the town and harbour only in the 29th plate, though it would have been much better for the reader's information, to have added the road and entrance likewiſe; but this could not be brought into ſo ſmall a compaſs as to be inſerted in this book, without rendering the parts indiſtinct. From this the reader may form a judgment how to proceed, if he ſhould find himſelf employed in ſuch ſort of works: for nothing can be more inſtructive than examples of works executed; the precepts only, without them, will never make ſo ſtrong an impreſſion upon the mind as is required in the execution of any project, which muſt be perfectly well underſtood beforehand. Thoſe who are curious in ſeeing the manner of forming harbours, may conſult the ſecond part of M. *Belidor*'s Architect Hydrauliques, where they will find plans of the moſt noted harbours in *Europe*.

Before we finiſh this ſubject, we think it will not be improper to give the principal

* *N. B.* This plan has by miſtake been reverſed by the engaver; ſo that the king's harbour, which appears on the right, ſhould be on the left.

con-

Plate XXIX.



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J. Mynde sculp.

conditions required in a sea-port town, and which ought to be observed in the building such places.

First, the harbour is of the greatest importance to all places of trade by sea; it ought therefore to be well considered, whether there is one to be found, which is formed by nature, such as a bay, creek, or a bason, or if by the help of a little labour one may be made; for to make one entirely by art, becomes generally too expensive, and they can never be made so large as to contain a considerable number of ships; whether the road before the harbour has a sufficient depth of water for ships of great burthen to ride in it safely; whether there is good anchoring, and the ships may be safe in stormy weather, and especially that ships may enter by such winds as are most dangerous upon that coast; if the entrance can be defended against a strong fleet, by means of forts, castles, or batteries built on each side of it; and lastly, whether the ships, riding int he road and harbour, are safe against a bombardment.

Secondly, whether the chief or principal materials for building the fortification and the town, are to be had near the place, or thereabouts; such as stone, timber, lime, &c.

or if not, whether they can be brough by water, otherwise the construction of such a place would be attended with an immense expence; whether the country round about is plentiful in those things which are necessary for the sustenance of men and cattle; for should it be barren, the bringing these necessaries from distant countries might be attended with great difficulties, especially in time of war, when an enemy might intercept them, and thereby reduce the place by famine; whether the air is good and the situation wholesome in all respects, and good water to be found near or thereabouts; for if it should be unwholesome, people would not care to settle there, and those that would venture, would neither increase or act with that spirit and chearfulness required for the improvement of new settlements; and as to good water, it is so necessary, that it is impossible to do without it; lastly, it should be considered, whether the country round about it produces such commodities as are fit for trade; how it may be improved, and where it may be transported to, either for sale or exchange, for some others which may turn to account either at home or abroad.

All

All these things being well considered, together with the nature of the ground, the plan of the place must be made accordingly; in which the construction of the works ought neither to be excessive in the expence for building of them, nor yet so small as not sufficiently to defend the place, but such as the importance of the place requires, and the situation admits of. As there are few situations which have all the advantages which could be desired, care must be taken to pitch upon such as have most of them, and where the rest may be supplied partly by art.

The most favourable situations for building maritime towns, are near the mouth or entrance of a navigable river, especially when it is free from rocks and sands, and is of easy access for shipping. In such situations, the harbour may be made on the opposite side of the place, in respect to the sea, as at *Ostend*, and some other places.

If the river is large, the place may be built at some distance from the sea, as *Antwerp*; and there is no occasion for a particular harbour, the river itself being sufficient; the only thing to be observed is, that there may be some place, where ships may be safe in stormy weather; a hill or rising ground near the ri-

ver, which ſhelters it from the moſt dangerous winds, will be very advantageous for that purpoſe.

Theſe ſituations near large navigable rivers, not too far from the ſea, are the moſt advantageous that can be found; for they have all the advantages of a ſea-port town, and are not liable to be attacked by an enemy's fleet, and are abſolutely free from bombardment, excepting by land, ſince a few forts built in the turnings of a river will be ſufficient to prevent any attempt that way: beſides, the merchandiſe brought by water may be carried into the country to foreign markets with little trouble, and no great expence.

As the greateſt wealth of a country depends on traffick by ſea, ſo there is nothing of ſo great conſequence, as the well protecting it, by building proper harbours to contain ſhips in ſafety, and to make them ſo, that they may be defended againſt the force or ſtratagem of an enemy: proper landing places ſhould not be omitted, nor good magazines and convenient ſtore-houſes to lodge the goods in, and, in general, every thing ſhould be thought of that any ways may contribute to eaſy conveyances, and the proper diſpoſing of them. But as nature is ſo various in

its

its operations, that it is impoſſible to foreſee all the different circumſtances which may happen, ſo it is likewiſe impoſſible to deſcribe them, and conſequently the choice of a proper ſituation, and the manner of conſtructing ſuch a place, according to its importance, muſt be referred to the ſagacity of the engineer employed in the undertaking, who certainly can have no larger field to diſplay his knowledge, than on ſuch occaſions.

Of Citadels.

In a country newly conquered, or one of a long ſtanding, where the inhabitants are ſuſpected of being diſaffected to the government, citadels are built to keep them in awe, and prevent all attempts they may make to ſhake off their dependency; as likewiſe to ſecure the garriſon from any treachery, which they might be willing to undertake againſt them.

It happens likewiſe ſometimes, that when a town is large and wealthy, and has little or no fortification, a citadel is built to ſecure it againſt an enemy, when it would be too expenſive to fortify the town itſelf; and to ſerve for a place of ſecurity, to carry in the beſt effects of the inhabitants in time of dan-

ger, when the approach of an enemy is apprehended.

There are many ſuch places in *Italy*, which are large and wealthy, the ſovereigns of which not being in a condition to fortify them, build citadels or caſtles, to ſave expences; as likewiſe to ſave large garriſons to guard and defend them.

In regard to the ſituation of a citadel, if the town lies in an open country, it ought to be built on the higheſt part of the ground, in order to command all the parts of the town, if poſſible; if the town lies near a navigable river or lake, it ſhould be placed near the entrance, to prevent the approach of an enemy with ſhips; and if the place is a ſea-port, the citadel ſhould be placed near the harbour, ſo as to command it from one end to the other; that it may protect the ſhips lying in it, and ſecure the place againſt any bombardment.

Another conſideration ſhould be had in placing citadels, with reſpect to the town; which is, that the principal ſtreets of the place ſhould be ſeen and lie open to the works of the citadel, in order to fire on them and diſperſe the mob that might riſe and flock together in time of a ſedition; as likewiſe to prevent the approach of an enemy that way after the town is taken.

An open ſpace, of ſome hundred yards broad, ſhould be left between the works of the citadel and the town, called an *Eſplanade*; which ſerves chiefly to draw up the troops or garriſon, to muſter and exerciſe them there; as likewiſe to prevent any hidden approach that might be carried on from the town againſt the citadel.

The figure of a citadel may be either a ſquare, pentagon, or exagon; but the pentagon is moſt proper, and generally uſed; the exagon being rather too big for that purpoſe, as requiring too great an expence in the building, in proportion to its uſe, or the advantage ariſing from it; and the ſquare is thought too inconſiderate for making a ſufficient defence.

When a citadel is to be built, either to an old place already fortified, or to a new one, its plan is to be traced by itſelf on a piece of paper, and upon the ſame ſcale as that of the town; then the paper is cut off on that ſide which is to be next to the town, quite cloſe to the edge of the works, and is laid on that of the town in ſuch a manner, that the ditches and works of the fortification are well flanked and enfiladed by the works of the citadel; and when it is placed according to its proper

situation, it is pricked off, and drawn upon the same paper as that of the place.

It happens sometimes that there is a hill, or rising ground, within the fortification of the place, on which the citadel is built; such situations may serve to keep the inhabitants in awe, if it is provided with necessaries, that the garrison may defend themselves, till such time that a relief may be sent; but they are of no manner of use against an enemy, who, after being in possession of the town, may easily reduce the garrison in the citadel by famine.

The exterior sides of the citadel are generally about 150 toises; but they may be more or less, as occasion requires. Particular care must be taken, to fortify the citadel stronger than the town, otherwise the enemy might attack it first, and by the help of which reduce the town; it must also be observed, to make the parts where the citadel joins the town sufficiently strong, otherwise the town and citadel might be attacked together. Most citadels that I have seen are defective in that respect, as we shall shew hereafter.

There are generally two gates made to a citadel, the one for a communication with the town, and the other with the country; the

the first serves for the garrison to retire into; in case of a sedition, or after the town has capitulated, and the other to receive succour, when the town is taken, or the citadel is blocked up by the inhabitants.

The citadel takes up generally two sides of the fortification, and ought to be placed in such a manner, that the ditch of the place may either be defended by the faces of the bastions, or by those of the ravelins, in as direct a manner as possible; otherwise the enemy may attack the town in that place, as being weakest; as likewise because the same attacks may serve to reduce both together. The covert-way of the citadel ought to be uninterrupted, so that the part next to the town may have a free communication with the other.

In general, a citadel should be constructed in such a manner, that an enemy may have no advantage wherever they made their attacks; and that, if the citadel is attacked first, it may cost them as much time and trouble, as the attacking the town first, and the citadel afterwards.

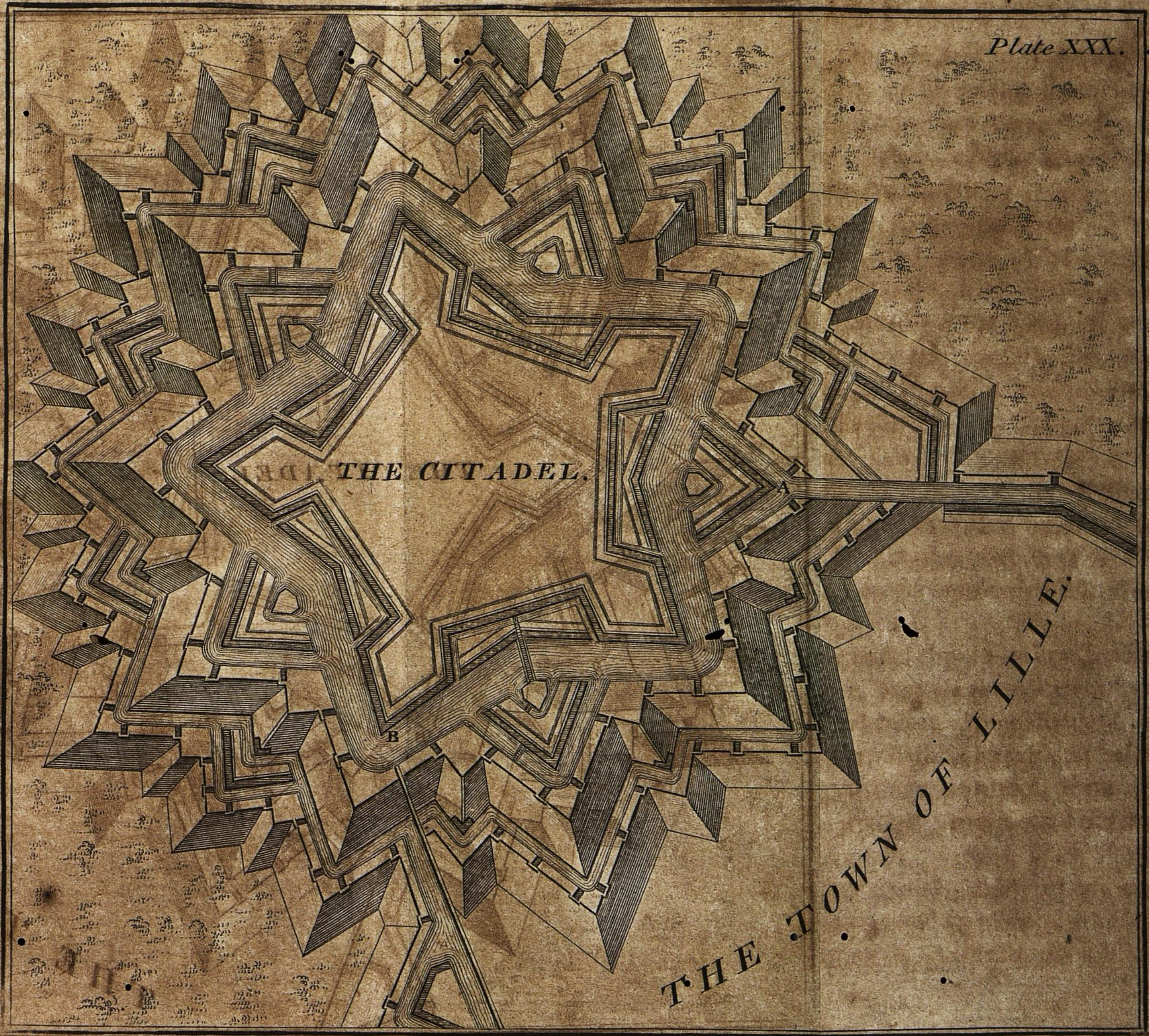
There are few citadels, that, in my opinion, are rightly joined to towns; the defence of the ditch is generally so oblique and

and insignificant, that it appears strange they are not attacked there; that of *Lille* is one PI.XXXI. of this kind. For the ravelin A cannot defend the opposite ditch in the least manner, nor is there any other work that can; so that if the town was attacked in that place, the besiegers would meet with very little obstacle in the passage over this ditch; neither does the bastion B defend the opposite ditch, which can be done only by the opposite covert-way, from which the troops may easily be driven by the ricochet batteries.

This plan is as the citadel has been built at first, but at present the second ditch and covert-way towards the town have been taken away, and new counterguards have been built before all the bastions; and retrenchments have been made in the faces of these counterguards: which is a practice the *French* follow in all the counterguards and tenaillons, whether constructed already, or when they make new ones.

PI.XXXI. The citadel of *Tournay* is another instance of this kind; for neither the ravelin A, nor the bastion B, can afford any tolerable defence to the opposite ditches; and as they are both dry, they are liable to serve an enemy for making their trenches in them under cover,

Plate XXX.



Muller delin.

J. Mynde sculp.

Müller delin | J. Mynde sculp

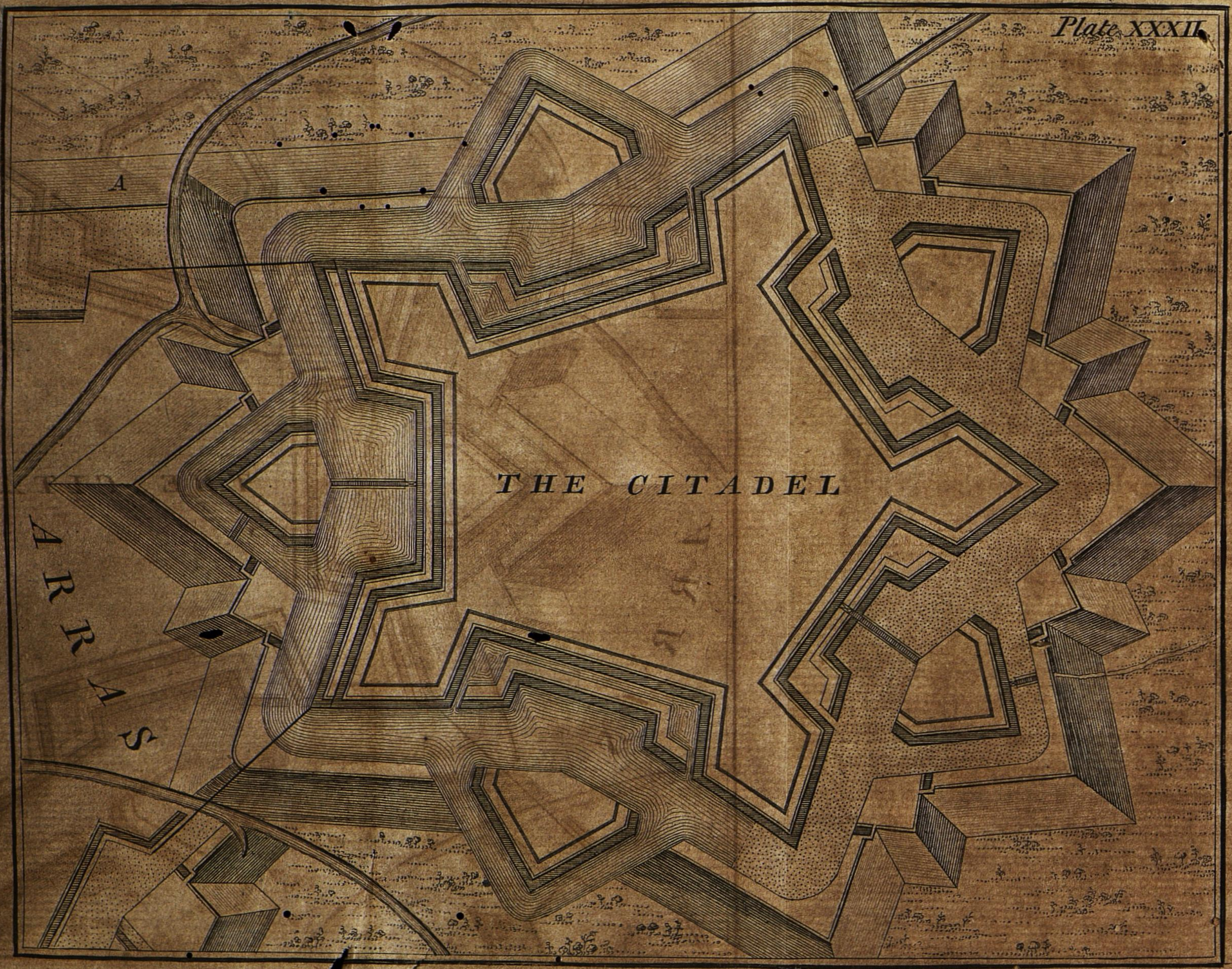


Plate XXXII.
A
THE CITADEL
ARRAS

cover. This General *Schullenbourg* was so sensible of, as not to let slip the opportunity, when he attacked that place in Queen *Anne*'s war; for he carried his approaches through that before the bastion B, and erected a mortar battery there; whereby the prodigious works above and underground of this citadel, which is esteemed to be one of the strongest in *Europe*, were of no manner of use.

It is a matter of surprise, that an engineer should take so much pains in fortifying a place, as M. *Maigrigny* did, and put a nation to so great expence, without considering rightly, whether it may make a defence accordingly, or having a due regard, in making every part equally strong, so as not to lose the advantage proposed by it, by neglecting some, whereby the whole expence is entirely lost, to the great disadvantage of a nation.

Lastly, the citadel of *Arras* is still in a worse place than either of the foregoing ones; for I do not see what should prevent an enemy from attacking the town near the citadel in the place A, since the troops being once driven out of that part of the covert-way, which is opposite to the ditch, by the ricochet batteries, which may soon be done, they might then as easily pass the ditch, as if there was no citadel; Plate XXXII.

del; by which all the great works about the reſt of the town would not be of the leaſt uſe.

Before we finiſh this ſubject, it will perhaps not be improper to ſay ſomething farther of citadels in general. When they are built with an intention to keep the inhabitants, who are diſaffected to the government, in awe, methinks they need not be fortified ſo ſtrongly as is cuſtomary; for if the garriſon can only hold out till ſuch time that ſuccour may be ſent, it would be ſufficient: for which reaſon, if the town is fortified, by cutting off two baſtions only, with ſome good retrenchment; it would anſwer the ends propoſed as well, as the adding another fortification of ſo great expence, as is moſt commonly practiſed: and as theſe ſupernumerary fortifications add but very little ſtrength to the place in proportion to the expence, it appears to me, that if a part of that expence were employed in adding more works to the town itſelf, it would be of more advantage.

The little defence made in the late war, by the citadels of *Lille* and *Tournay*, ſhould, one would think, cure a prince of making theſe ſorts of works ſo expenſive; but there ſeems to be a neceſſity of following the faſhion in fortification as well as in dreſs, to avoid appearing ridiculous. It

It may be ſaid, that the want of a good garriſon, ammunition, and other neceſſaries, was the occaſion of the ſhort defences theſe two citadels made: it may probably be, that they were obliged to ſurrender ſomewhat ſooner on this account. But if a large town is able to make as long a defence as there is any ammunition and troops to defend it; there ſeems to be not the leaſt occaſion for any more works, which can but little increaſe the ſtrength of the place.

Beſides, it is manifeſt, by what has been ſaid before, that a ſmall place ever ſo well fortified, and provided accordingly, can never make the defence, which a larger may do with leſs works in proportion.

Of Forts and Redoubts.

Forts are a kind of ſmall fortifications, Plate
built in order to guard ſome paſſes, in a moun- XXXIII.
tainous country, or near cauſeways, rivers, and other ſuch like places. Their figure and bigneſs are various, and depend chiefly on the nature of the ſituation, and importance of the place: ſometimes they are only made triangular, as in the firſt figure, with half Fig. 1
baſtions; but this ſort is very imperfect, becauſe the faces are not ſeen or defended from

any

any other part. If inſtead of being terminated at the angle, they were directed to a point within about 20 toiſes from it, they would be much better, as being then defended by that length of the rampart, though very obliquely. There ſhould be a ditch of 8 or 10 toiſes about this fort, although we have not marked it in this figure.

Fig. 2. Sometimes they are made as in the ſecond figure, that is, triangular, as before, but inſtead of making half baſtions at the angles, whole ones are placed in the middle of the ſides. The gorges of theſe baſtions may be from 20 to 24 toiſes, when the ſides are from a 100 to 120; the flanks are perpendicular to the ſides from 10 to 12 toiſes long, and the capitals from 20 to 24: if the ſides happen to be more or leſs, the parts of the baſtions are likewiſe made more or leſs in proportion; the ditch round this fort may be 10 or 12 toiſes wide.

The ramparts and parapets of theſe ſorts of works are commonly made of turf, and the outſide of the parapet fraiſed; that is, a row of palliſades are placed in about the middle of the ſlope, in an horizontal manner, the points declining rather a little downwards, that the grenades or fire-works thrown

upon them, may roll down into the ditch: and if the ditch is dry, a row of palifades ſhould likewiſe be placed in the middle of it, to prevent the enemy from paſſing over it unperceived, and to ſecure the fort from any ſurpriſe.

Forts are moſt commonly made ſquare, as in the third figure; at leaſt, when the paſs they are to guard is of any conſequence, or the place may eaſily be approached; the ſides of this ſquare are 100 toiſes, the perpendicular 10, and the faces 25; the ditch about this fort may be from 10 to 12 toiſes; the parapet is to be made of turf, and fraiſed, and the ditch paliſaded when dry. There may be made a covert-way about this fort, or elſe a row of paliſades might be placed on the outſide of the ditch. Fig. 3.

They are often made of various figures, regular or irregular, ſometimes in the form of a ſemi-circle, eſpecially when they are ſituated near a river, ſea, or at the entrance of a harbour; by which figure, they are able to fire at the ſhips on all ſides of it; at others with a long ſide, and ſeveral ſmall ones without any baſtions; this ſhould however not be done, but when they cannot be approached, without much time and difficulty: for it is

not ſuppoſed that any fort can hold out long againſt a ſuperior force provided with artillery; their intent is only to prevent parties of an enemy to paſs that way, and to ſtop them for ſome time till they may be ſuccoured.

When a fort is to be built in the neck of land, formed by the confluence of two rivers, or in the windings of a river, in order to prevent an enemy from tranſporting any thing by water, or to prevent the paſſing of their ſhips that way; the figure of the fort muſt be adapted to the ſituation, in ſuch a manner, that there may be no place for landing troops, but what can be diſcovered by the fire of ſome work or other, and the ſide next to the land ſhould always be better fortified than the other parts near the river; as being more liable to be attacked.

Fig. 4. The fourth figure repreſents ſuch a fort; three ſides of which are a 100 toiſes each, and the fourth but 50, as ſuppoſing the ground to be narrow in that place; the perpendiculars to the greateſt ſides are 14, and the faces 30; the perpendicular to the other 10, and the faces 15: the capitals of the ravelins 25; the great ditch 12; that before the ravelin 8, and the covert-way 4 or 5. The narrow front towards the land is covered by

by a horn-work, whoſe front is at the diſtance of 36 toiſes from that of the fort, and 90 long, the perpendicular 12, faces 25, and the branches 10 toiſes broad at their extremities; the capital of the ravelin before this work is 22 toiſes, the ditch before the horn-work 8, and that before the ravelin 6 or 7.

We ſhall add another example of this kind, ſuch as is repreſented by the fifth figure: Fig. 5. the land is ſuppoſed to open gradually; for which reaſon three ſides are 100 toiſes each, and the fourth 160; the perpendiculars to the ſhorteſt 12, and the faces 30; that to the greateſt 20, and the faces 45: the ditch before the three ſhort ſides is 12, and 18 before the greateſt. The capital of the ravelin is 46 toiſes, its ditch 10; the faces of the lunettes are at right angles to thoſe of the ravelin, and fall within 16 toiſes from the ſaliant angle; theſe faces are 25 toiſes long, and the others are perpendicular to thoſe of the baſtions; the narrow part of the bonnet is 10 toiſes, and the faces are perpendicular to thoſe of the lunettes, or parallel to thoſe of the ravelin; the ditches before the lunettes and bonnet are 8 toiſes, and the covert-way 4.

There are generally great faults committed in the constructions of forts near the sea, or navigable rivers, for want of rightly considering all the different circumstances attending these sort of works, and without which it is impossible that a work will ever answer the intents and purposes for which it was built. For instance, if a battery or fort, built near the water where ships may approach, has its parapet not of a sufficient height; those behind them may be fired upon, from the round-top of the mast, by which the gunners are obliged to abandon their guns, to save themselves by flight; and so these forts or batteries become of little or no use.

This was the case at *Portobello*, when attacked by Admiral *Vernon*; for the forts and batteries, which were designed to defend the harbour, had been made so low, that the ships could come quite close to them, and the troops in them were soon obliged to take to their heels and run away.

There is generally another fault committed, which is, that if these forts or batteries are left open behind, or are very little fortified towards the land, the enemy may land men in the dark and surprise them, by which the

guns placed in them become not only useless to the place, but serve rather to destroy it.

At *Carthagena* the *Spaniards* had a fascine battery on the other side of the entrance into the harbour, opposite to the camp, by which they prevented ships from going in; sailors were sent to take it, which was soon performed; but being satisfied with driving only the *Spaniards* from it, they were obliged to take it a second time to nail up the guns.

The same thing happened last war at *Cape Breton*, where the *French* had a battery of 15 large pieces of cannon; which the *English* surprised in the dark, and turned the cannon against the place, whereby they became soon masters of it. This fort was quite open behind, which being surprised by the sailors in the night, as we said, turned the cannon against the town and took it. Whereas if this battery had been secured in a proper manner, we might perhaps not have been able to take it, or at least it would have lengthened the siege considerably. Many examples might be cited of this kind, to shew, that the want of judgment in building these forts has proved a detriment, instead of an advantage, to the places which they should have defended.

To prevent the inconveniency of being ſeen behind the parapet, it will be neceſſary to make them 9 or 10 feet high, and to cover the batteries overhead, which may be done, by making an arch over every piece, left open behind to let out the ſmoke; but if this ſhould be thought too expenſive, they might be covered with planks, like ſheds; and to prevent the wood being ſet a-fire, they may be covered with earth or dung about a foot and a half thick: for if it is but ſtrong enough to reſiſt muſket-ſhot, it is ſufficient.

And to prevent a fort or battery being ſurpriſed, they ſhould be fortified all round with a good rampart and ditch at leaſt, or with an addition of outworks, if the place is of any importance; the rampart muſt be fraiſed with paliſades, if it is made with turf, and the ditch ſhould have a row of paliſades, planted in the middle of it, in caſe it is dry; which will prevent an enemy approaching unperceived.

It has been the cuſtom, in latter times, for ſhips to approach forts and deſtroy them without any concern, as knowing too well the little danger they expoſe themſelves to; and this has been occaſioned by their bad conſtruction; whereas, if they were made

as

as they ſhould be, it would not be impoſſible to ſink every ſhip that ſhould dare venture to come near them. The reaſon of this is plain, if we conſider the uncertainty there is to fire from a ſhip, which is in a continual motion, and that a battery, covered with a good parapet, may watch the opportunity, when the ſhip comes near and oppoſite to it, and fire all the guns at once, pointing nearly at the ſame place a little above the water, which will hardly fail of deſtroying it.

On the contrary, if the guns of the ſhip hit the battery by chance, they can do it but little or no damage, when the parapet is well made.

There are ſome who are of opinion, that ſhips will always be able to deſtroy a fort, on account that they have more guns within a leſs compaſs than any battery on land can have; and if the contrary happens, it is more owing to the cowardice of the commander, than to any thing elſe, but this is a wrong notion, as we ſhall make appear. For ſuppoſe a firſt rate man of war, which has three decks, and therefore may have perhaps four, five, or ſix guns to one; the chance of hitting the battery, on account of the ſhip's motion, is not above three to one; and when the ſhot

ſtrikes the parapet, it can do it but very little damage, excepting it ſhould hit a gun by chance, which it would diſmount; but this is not ſo eaſily done, conſidering the ſmallneſs of the gun with regard to their intervals; it is certain not one gun in 30 will hit; whereas the battery may watch the opportunity, ſo as when the ſhip comes near and oppoſite, to make a general diſcharge with all the guns, where there will be not one that miſſes, and every ſhot will make its hole into the ſhip, and deſtroy all things that are in its way. From whence it may be concluded with juſtice, that ſhips are never able to deſtroy any fort, when it is conſtructed in the manner it ſhould be.

If the nature of the ground is ſo as to admit of making two batteries, one above the other, it ſhould not be neglected; the one nearly a level with the ſurface of the water, to fire in a horizontal direction, and the other to plunge into the ſhips; ſo that if the troops are placed on the lower, being well protected in the front by a high parapet, and covered above with arches or planks, it will not be in the power of ſhips to deſtroy them, as has been done heretofore.

If there are any flates of ſand, or rocks, near or within the entrance of a harbour, it will be very proper to build ſome tower or fort there of ſeveral ſtories, well arched, ſo as to be bomb-proof, in order to place ſeveral ranges of guns in them; but as the ſmoak might be troubleſome in the lower ſtories, I would make it open in the middle, that is, I would make two concentric walls, ſo that the arches of the roofs of the lower ſtories might be quite open behind; and in caſe the enemy ſhould throw ſhells, and hit the upper battery, it might be ſo contrived, that the ſhells may roll down the opening in the middle without doing any damage.

Fort *St. Louis*, in the road before the harbour of *Toulon*, is ſuch a work, of a round form, built upon a rock, within the water; and the towers called *Egillette* and *Vignette*, are places of the ſame nature in a ſquare form, built upon the necks of land on both ſides of the mouth of the road.

It is the cuſtom of ſome modern engineers, when they build any fort or battery near the ſea or navigable rivers, to make a parapet of three feet high only, in order to fire the guns en barbet; the reaſon they give for this practice is, that they may point the guns which

way they pleaſe, either down the river, to prevent the ſhips from approaching, deſtroy them when they are oppoſite, or firing after them in caſe they ſhould paſs. However ſpecious theſe reaſons appear at firſt, yet when it is rightly conſidered, it will be found that this practice is not ſo advantageous as they imagine. For if they fire at the ſhips when they are yet far off, they can do them but very little damage; and the advantage gained thereby will not by far be equivalent to the danger they will themſelves be expoſed to, when the ſhips come near; ſince one broad ſide, together with the fire of the ſmall arms, will be ſufficient to kill or diſable all thoſe which are on the battery. On the contrary, if the batteries are well covered in the front by a good parapet, and above by planks, or only ſail-cloth, and made in ſuch a manner, as that ſome guns may be directed down the river, and others upwards; this battery will have all the advantage which they can pretend to gain by their practice, and none of its diſadvantages.

Another method is alſo uſed in forts, much more defective than this, which is, to build the parapets of brick or ſtone only, without any earth behind it; for as ſoon as the

the ſhips come once within reach of the fort or batteries, they may eaſily deſtroy this parapet, and the pieces of ſtones or bricks will be more dangerous to the defenders than the enemy's ſhot itſelf. And it has been found by experience, that nothing diſheartens troops placed behind a wall ſo much as the pieces of ſtone flying about their ears, and therefore ſuch a practice ſhould be avoided as much as poſſible; beſides, the adding 10 or 12 feet of earth only to the wall will be but a trifling expence, and yet ſufficient to protect the troops from this danger.

Having explained the methods of the moſt celebrated authors, and carefully examined their conſtructions, to the beſt of our judgment, without the leaſt partiality, we hope to have done all that is neceſſary to complete the elementary part of fortification; which being well underſtood, will, I hope, be ſufficient for underſtanding the ſubject; and to leave nothing that might any ways contribute to the reader's ſatisfaction, we ſhall ſubjoin the following explanation of the principal terms uſed in fortification, by way of a dictionary, to which recourſe may be had, when there is any occaſion for it.

An

An Explanation of the principal terms used in Fortification, digested in an alphabetical manner.

A.

ANGLE of the center of a polygon, is formed by two radii drawn to the extremities of the ſame ſide.

Angle of the polygon, is made by the concourſe of two adjacent ſides of a polygon.

Angle of the flank, is made by the curtain and the flank.

Angle of the ſhoulder, is made by the face and flank of the baſtion.

Approaches, are a kind of roads or paſſages ſunk in the ground by the beſiegers, whereby they approach the place under cover of the fire from the garriſon.

Arrow, is a work placed at the ſaliant angles of the glacis, and conſiſts of two parapets, each 40 toiſes long; this work has a communication with the covert-way of about 24 or 30 feet broad, called caponier, and a ditch before it of 5 or 6 toiſes.

Aſſault, is a ſudden and violent attack, made uncovered, on the part of the rampart where a breach has been made.

Attack, is the manner and diſpoſition made by an army or a great party, to drive an enemy out of a fortified place, or of any kind of ſtrong ſituation.

B.

Barbet, when the parapet of a work is but three feet high, or the breaſt-work of a battery is only that height that the guns may fire over it without being obliged to make embraſures, it is ſaid that the guns fire en barbet.

Baſtion, is a part of the inner incloſure of a fortification, making an angle towards the field, and conſiſts of two faces, two flanks, and an opening towards the center of the place called the gorge.

A baſtion is ſaid to be full, when the level ground within is even with the rampart, that is, when the inſide is quite level, the parapet being only more elevated than the reſt.

And a baſtion is ſaid to be empty, when the level ground within is much lower than the rampart, or that part next to the parapet, where the troops are placed to defend the baſtion.

Banquette, is a kind of ſtep made on the rampart of a work near the parapet, for the troops to ſtand upon in order to fire over the parapet;

parapet; it is generally three feet high, and as many broad, and $4\frac{1}{2}$ feet lower than the parapet.

Battery, is a work made to place guns or mortars on it; consists of an epaulement or breast-work of about 8 feet high, and 18 or 20 thick; when it is made for guns, openings or embrasures are made in it, for the guns to fire through them.

Berm, is a little space or path of 6 or 8 feet broad, between the ditch and the parapet, when it is only made of turf, to prevent the earth from rolling into the ditch, and serves likewise to pass and repass.

Blind, is two sticks fastened together by two spars of about 4 feet asunder; they serve to cover the saps, or to keep up the earth on the sides, by placing fascines behind them.

Blockade, is the encompassing a fortified place with an army, so that it must either be starved or surrender.

Body of the place; although the buildings in a fortified place are properly said to be the body of the place, yet the inclosure round them is generally understood by it: for it is said, to construct the body of the place, which means no more than to fortify or inclose the place with bastions and curtains.

Bombs,

Bombs, are the name of the ſhips which carry mortars.

Bombardment, is when a great number of ſhells are thrown into a place, to ruin and deſtroy the buildings.

Bonnet, is a ſort of work placed before the ſaliant angle of the ravelin to cover it.

Barracks, are thoſe piles of buildings made on purpoſe to lodge the ſoldiers in them.

Breach, is an opening made in a wall or rampart, with cannon or mines, ſufficiently wide for a body of troops to enter the works and drive the beſieged out of it.

C.

Capital of a work, is an imaginary line which divides that work into two equal and ſimiliar parts.

Capitulation, is the agreement made by the beſieged with the beſiegers, on what conditions the place is to ſurrender.

Camp, is the ſpot of ground occupied by an army for a night or more, and where they pitch their tents.

Caponier, is a paſſage made from one work to another, of 10 or 12 feet wide, covered on each ſide by a parapet, terminating in a ſlope or glacis.

Thus when the ditch is dry, the passage from the curtain to the ravelin, or that from the covert-way to the arrows or detached redoubts, are calle caponiers.

There are often single parapets raised at the entrance of the ditch, before the ravelin, to place small cannons and men behind them to dispute the passage over that ditch, which are likewise called caponiers.

Cavalier, is a work raised generally within the body of the place, ten or twelve feet higher than the rest of the works. Their most common situation is within the bastion, and made much in the same form; sometimes they are also placed in their gorges, or on the middle of the curtain; they are then made in the form of a horse-shoe, only somewhat flatter.

The use of cavaliers is to command all the adjacent works and country about it; they are seldom or never made but when there is a hill or rising ground which overlooks some of the works.

Casemat, is a work made under the rampart, like a cellar or cave, with loop-holes, to place guns in it.

Chamade; when the governor of a place besieged wants to capitulate, then the drums

beat on the rampart next to the attack, which is called chamade.

Cheavaux de Frize, are large joists or beams stuck full of wooden pins armed with iron, to stop breaches, or to secure the passages of a camp against the enemy's cavalry.

Covert-way, is a space five or six toises broad, going quite round the works of a fortification, and is adjoining to the counterscarp of the ditches, covered by a parapet $7\frac{1}{2}$ feet high, terminating in an easy slope towards the field, at a distance of 20 toises.

Center of the bastion, is the point within where the two adjacent curtains produced intersect each other.

Citadel, is a kind of fort or small fortification of four, five, or six sides, joined to towns, when the inhabitants are suspected to be disaffected to the government.

Command, when a hill or rising ground overlooks any work of a fortification, and is within the reach of cannot-shot; this hill is said to command that work.

Chamber, is that place of a mine where the powder is lodged.

Countermines, are the mines made within the fortification, either at the same time the place is fortified, or afterwards in the time of a siege. *Coun-*

Counterſcarp, is the outſide of a ditch, oppoſite to the parapet of the work behind the ditch; it is often ſaid, that the beſiegers have carried their lodgements upon the counterſcarp, which means, they are lodged on the covert-way.

Counterguard, is a work placed before the baſtions to cover the oppoſite flanks from being ſeen from the covert-way: they are likewiſe made before the ravelins.

When they are placed before the baſtions, they are eſteemed to be of a very good defence.

Crown-work, is a kind of work not unlike a crown; it has two fronts and two branches; the fronts are compoſed of two half baſtions and one whole one; they are made before the curtain or the baſtion, and generally ſerve to incloſe ſome buildings which cannot be brought within the body of the place, or to cover the town-gates, or elſe to occupy a ſpot of ground which might be advantageous to an enemy.

Cordon, is a round projection made of ſtone in a ſemi-circular form, whoſe diameter is about 8 inches, which reigns quite round the wall, within four feet from the upper part.

Curtain,

Curtain, is the part of the body of the place, which joins the flank of one baſtion to that of the next.

Cuvette, or rather *Cunette*, is a ſmall ditch of 10 or 12 feet broad, made in the middle of a large dry ditch, ſerving as a retrenchment to defend the ditch, or elſe to let water in it, when it can be had in the time of a ſiege.

Counterforts, or *Buttereſſes*, are ſolids of maſonry, built behind walls, and joined to them, at 18 feet diſtance from center to center, in order to ſtrengthen it, eſpecially when it ſuſtains a rampart or terras.

Communication, is a paſſage from one work to another, covered by a parapet on each ſide. See *Caponiers*.

D.

Decagon, is a polygon or fortification of ten ſides.

Demi-lune, or *Ravelin*, is a work placed before the curtain to cover it, and prevent the flanks from being diſcovered ſideways; it is made of two faces meeting in an outward angle.

Detached baſtion, is that which is ſeparated from the reſt of the body of the place,

 and

and is made in the ſame manner as thoſe which are joined to the body. Counter-guards with flanks are alſo called detached baſtions, as in M. *Vauban*'s ſecond and third methods.

Detached redoubt, is a work made at ſome diſtance from the covert-way, much in the ſame manner as a ravelin with flanks.

Ditch, is a large deep trench made round each work, and the earth dug out of it ſerves to raiſe the rampart and parapet.

Dodecadon, is a figure or fortification of twelve ſides.

E.

Eſcarp, is properly any thing high and ſteep, and is uſed in fortification to expreſs the outſide of the rampart of any work next to the ditch, as being high and ſteep.

Embraſures, are openings made in the flanks of a fortification, or in the breaſt-work of a battery, of about $2\frac{1}{2}$ feet within, 8 or 9 without, and 3 from the bottom, for the guns to enter partly, and to fire through.

Enfilade, a work is ſaid to be enfiladed, when a gun may fire into it, ſo that the ſhot may go all along the inſide of the parapet.

Epaulement, is a kind of breaſt-work to cover the troops in front, and ſometimes in flank:

In a ſiege, the beſiegers raiſe generally an epaulement of 9 or 10 feet high, near the entrance of the approaches, to cover the cavalry, which is placed there to ſupport the guard of the trenches.

Eſplanade, is an open ſpace between the citadel and town, to prevent an enemy from making approaches under cover, after he is maſter of the place.

Enneagon, is a nine-ſided figure or fortification.

Eptagon, a ſeven-ſided one.

Exagon, a ſix-ſided one.

Exterior ſide of a fortification, is the diſtance or imaginary line drawn from one point of the baſtion to that of the next.

F.

Faces, of the baſtion, are the two ſides which meet in an angle projecting towards the field.

Faces, of any work, are thoſe parts where the rampart is made, making an angle pointing outwards.

Fascine, a kind of faggot made of branches tied in two or more places of about 6 or 8 inches diameter.

They serve to keep up the earth in trenches, as likewise in batteries, instead of stone or brick walls.

When they are used in raising batteries, they are generally 16 feet long; and are then called *Saucissons*.

Fausse-bray, is a low rampart going quite round the body of the place; their height is about 3 feet at most above the level ground; and its parapet is about 4 or 5 toises distance from that of the body of the place.

These works have been intirely rejected by the modern engineers, excepting M. *Vauban*, who makes them only before the curtains, and then they are called tenailles.

Flank, in general, is a part of a work, which defends another work along the outside of its parapet.

Flank of the bastion, is the part between the face and curtain; the flank of one bastion serves to defend the ditch before the curtain, and face of the opposite bastion.

Flank (concave) is that which is made in an arc of a circle.

Flank (retired) is that which is made behind the line, which joins the extremity of the face and the curtain, towards the capital of the baſtion. M. *Vauban* makes his 5 toiſes from that line, others more or leſs, as it happens.

Flanking, is the ſame thing in fortification as defending.

Flank (direct or graſing) is that which is perpendicular to the oppoſite face produced; and oblique or fiſhant, when it makes an acute angle with that face.

Flank (ſecond) when the face of a baſtion produced, does not meet the curtain at its extremity, but in ſome other point; then that part of the curtain between that point and the flank, is called ſecond flank. The modern engineers have rejected this way of fortifying.

Fort, is a ſmall fortification, made in a paſs, near a river, or at ſome diſtance from a fortified town; to guard the paſs, or to prevent the approach of ſhips, or an enemy by land.

Fortification, is a general name for any work made to oppoſe a ſmall number of troops againſt a greater.

Fourneau, is the place of a mine, where the powder is lodged, and is the ſame thing as the chamber of a mine.

Fougaſs,

Fougafs, is a fmall mine, from 6 or 8 feet under ground; they are generally placed under the glacis or dry ditches.

Fraife, a kind of ftakes or palifades placed horizontally on the outward flope of a rampart made of turf, to prevent the work being taken by furprize.

When an army retrenches itfelf, they often fraife the parapets of their retrenchments in the parts moft expofed to being attacked.

Fufee, is the piece of wood drove into grenades or fhells, being hollow, and filled with mealed powder, by which the grenade or fhell is fired.

G.

Gabion, is a cylindric bafket open at both ends, of about 3 feet wide, and as much in height; they ferve in fieges to carry on the approaches under cover, when they come pretty near the fortification.

Gabion, (ftuft) is made in the fame manner as the former, they are only filled with all forts of branches and fmall wood, and are 5 or 6 feet long; they ferve to roll before the workmen in the trenches, to cover them in front againft mufket-fhot.

Gallery,

Gallery, is the paſſage made under ground leading to the mines; they are from 4½ to 5 feet high, and about 4 feet broad; the earth above is ſupported by wooden frames with boards over them.

Garriſon, a body of troops compoſed of horſe and foot, placed in a fortification to guard it in time of peace, and to defend it in time of war, in caſe an enemy ſhould attack it.

Glacis, is that part of a fortification beyond the covert-way, to which it ſerves as a parapet, and terminates towards the field in an eaſy ſlope at about 20 toiſes diſtance.

Gorge, of a baſtion, is the interval between the extremity of one flank to that of the other.

Gorge, of any work, is that part next to the body of the place, where there is no rampart or parapet; that is, at the counterſcarp of the ditch.

Grenade, is an iron ball of about 3 inches diameter hollow within; which is filled with powder, to be thrown by the grenadiers amongſt the enemy in an attack, after having ſet fire to the fuſee, that it may burſt.

H.

Hornwork, is compoſed of a front and

two branches; the front is made into two half baſtions and a curtain: this work is of the nature of a crown-work, only ſmaller, and ſerves for the ſame purpoſes.

Half-moon; ſee *Demi-lune*.

Hurtor, is a piece of timber about 6 inches ſquare, placed before the wheels of a carriage, againſt the parapet of a battery, to prevent the wheels from doing damage to the parapets.

I

Inſult, a work is ſaid to be inſulted, when it is attacked ſuddenly and openly.

Inveſting a place, is to ſurround it with troops, ſo as to prevent any thing to enter the place, or to be carried out of it: it is the firſt operation of a ſiege.

Interior ſide of a fortification, is the imaginary line drawn from the center of one baſtion to that of the next, or rather the curtain produced to the centers of the baſtions.

L.

Line of defence, is the diſtance between the ſaliant angle of the baſtion, and the oppoſite flank; that is, it is the face produced to the flank.

Line

Line of circumvallation, is the work or retrenchment made about an army which besieges a place, to secure it against any insult from without; it is made of a parapet which a ditch before it, and at every 120 toises, or thereabout, the parapet projects outwards in an angle; this projection is called a *Redan*, and serves to flank or defend the other parts.

Line of countervallation, is the work made by an army which besieges a place between their camp and the town, to cover it against any enterprize of the garrison; it is made much after the same manner as the line of circumvallation, only in a contrary disposition.

Line, is also the name of the works made by an army from one town or strong post to another, behind which it is encamped, to guard a part of the country.

Line of counter-approach, is a kind of trench made by the garrison when besieged, going from the covert-way in a right line, so as part of the enemy's approaches may be enfiladed from thence.

Lodgment, is the work made by the besiegers in some parts of fortification, after the besiegers have been drove out, to maintain it.

Loop-

Loop-holes, are ſquare or oblong holes made in the wall, to fire through with muſkets.

Lunettes, are works made on both ſides of a ravelin; one of their faces is perpendicular to half or two thirds of the faces of the ravelin, and the other nearly ſo to thoſe of the baſtions.

Lunnettes, are alſo works made beyond the ſecond ditch, oppoſite to the places of arms; they differ from the ravelins only in their ſituation.

M.

Mantlet, is a kind of moving parapet made of ſtrong planks, about 4 feet long and 3 high, mounted upon two wheels, with a long pole fixed to it; they ſerve to cover the ſappers in the front againſt muſket-ſhot.

Mine, is a kind of lodgment made under ground to place powder in it, which is ſet on fire, in order to blow up the works above it; the difference between mines and countermines is, that the firſt are made by the beſiegers, and the latter by the beſieged.

Octa-

O.

Octagon, is an eight-sided figure of fortification.

Ondecagon, an eleven-sided one.

Orillon, is a part of the bastion near the shoulder, which serves to cover the retired flank from being seen obliquely.

Orgues, many harquebusses linked together or divers musket-barrels laid in a row, so that they may be discharged either all at once or separately; also long and thick pieces of wood with iron plates at the end, hung over a gate, to stop it up instead of a port-cullice.

P.

Palisades, are a kind of stakes made of strong split wood of about 9 feet long, fixed 3 feet deep in the ground in rows about 6 inches asunder; they are placed in the covert-way at 3 feet from, and parallel to the parapet or ridge of the glacis, to secure it from being surprised.

Parapet, is a part of the rampart of a work, of 18 or 20 feet broad, and raised 6 or 7 feet above the rest of the rampart: it serves to cover the troops, placed there to defend the work, against the fire of the enemy.

Parallels,

Parallels, or places of arms, are deep trenches 15 or 18 feet wide, joining the several attacks together; they serve to place the guard of the trenches in, to be at hand to support the workmen when attacked. There are generally three in an attack; the first is about 300 toises from the covert-way the second 190, and the third near or on the glacis; they were first invented or used by M. *Vauban*.

Petard, is a kind of a brass pot fix d upon a strong square plank, which has an iron hook to fix it against a gate or palisades; this pot is filled with powder, which when fired, breaks every thing about it, and thereby makes an opening for an enemy to enter the place.

Port-cullice, is a falling gate or door like a harrow, hung over the gates of fortified places, and let down to keep out the enemy.

Place, is commonly used in fortification instead of a fortified town.

Place of arms, of the covert-way, is a part of it, opposite to the re-entering angle of the counterscarp, projecting outwards in an angle.

Places of arms, in an attack; see *Parallels*.

Plat-

Plat-form, is a floor made of ſtrong planks, laid upon joiſts, on a battery, to place the guns or mortars upon, in order to prevent the wheels or mortar-bed from ſinking in the ground.

R.

Rampart, is an elevation of earth raiſed along the faces of any work, of 10 or 15 feet high, to cover the inner part of that work againſt the fire of an enemy.

Rams-horns, are a kind of low work made in the ditch of a circular arc; they were invented by M. *Belidor*, and ſerve inſtead of tenailles.

Re-entering angle, is that which turns its point towards the center of the place.

Ravelin. See *Demi-lune*.

Redans. See *Line of circumvallation*.

Redoubt, is a kind of work placed beyond the glacis, of various forms.

Redoubt, is alſo the name of a ſmall work made in a ravelin, of the ſame form.

Redoubt, is likewiſe a ſquare work without any baſtions, placed at ſome diſtance from a fortification, to guard a paſs, or to prevent an enemy from approaching that way.

Revete-

Revetement, is a ſtrong wall built on the outſide of the rampart and parapet, to ſupport the earth, and prevent its rolling into the ditch.

Ricochet, when guns are loaded with ſmall charges, and are elevated from 10 to 12 degrees, ſo as to fire over the parapet, and the ſhot rolls along the oppoſite rampart, it is called ricochet firing; and the batteries are likewiſe called ricochet batteries.

S.

Sally, is when a party of a garriſon goes out privately, and falls ſuddenly on the beſiegers in their trenches, endeavouring to drive them out and deſtroy their works.

Saliant angle, is that whoſe point turns from the center of the place.

Second ditch, is that which is made on the outſide of the glacis, when the ground is low, and water to be had.

Second covert-way, is that which is made beyond the ſecond ditch.

Sap, is a trench or an approach made under cover of 10 or 12 feet broad, when the beſiegers come near the place, and their fire grows ſo dangerous, as not to be approached uncovered.

Sauciſſon, is a long pipe or bag, made of cloth or leather, of about an inch and a half diameter, filled with powder, going from the chamber of a mine to the entrance of the gallery; it ſerves to give fire to the mine.

Sauciſſon, is likewiſe a faſcine much longer than the common ones; they ſerve to raiſe batteries, and to repair breaches.

Siege, is when an army approaches a fortified place, and ſurrounds it on all ſides, endeavouring to oblige the garriſon to ſurrender, either by deſtroying the works of the fortification, or whoſe which defend them.

T.

Talud, or ſlope, is made to the works of a fortification, both on the outſide and inſide, to prevent the earth from rolling down.

Traverſe, is a parapet made croſs the covert-way, oppoſite to the ſaliant angles of the works, and near the places of arms, to prevent enfilades; they are 18 feet thick, and as high as the ridge of the glacis. There are alſo traverſes made in the caponiers, but then they are called *tambours*.

Traverſes, are likewiſe made within other works, when there are any hills or riſing grounds, which may ſee the inſide of theſe works.

Tenailles,

Tenailles, are low works made in the ditch before the curtains; there are three sorts, *viz.* the first are the faces of the bastions produced, till they meet, but much lower; the second have faces, flanks, and a curtain; and the third, have only faces and flanks.

Tenaillons, are works made on each side of the ravelin, much like the lunettes; they differ, in that one of the faces of a tenaillon is in the direction of the face of the ravelin; whereas that of the lunette is perpendicular to it.

Tower bastions, small towers made in the form of bastions by M. *Vauban*, in his second and third method; with rooms or cellars underneath, to place men and guns in them.

The END.